CANADA

DEPARTMENT OF MINES

GEOLOGICAL SURVEY

HON. ROBERT ROGERS, MINISTER; A. P. LOW, DEPUTY MINISTER;
R. W. BROCK, DIRECTOR.

MEMOIR No. 33

THE GEOLOGY OF GOWGANDA MINING DIVISION

BY

W. H. COLLINS

OTTAWA
GOVERNMENT PRINTING BUREAU
1913

No. 1242

Frontpiece.

PLATE I.

26396

Photo by C. J. Wallis.

Gowganda.

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To R. W. BROCK, Esq.,

Director Geological Survey,

Department of Mines.

SIR,—I beg to submit to you the accompanying memoir upon the geology of a portion of Gowganda Mining Division and vicinity.

I have the honour to be, sir,

Your obedient servant,

(Signed) **W. H. Collins.**

May 27, 1911.

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GEOLOGY

OF

GOWGANDA MINING DIVISION AND VICINITY.

BY

W. H. Collins.

INTRODUCTION.

Position and Importance of the Area.

Veins carrying silver-cobalt ores were discovered near Cobalt, Ontario, in 1903. The ores—sulphides and arsenides of cobalt, nickel, and silver, like those mined at Silver islet, in Lake Superior, and in Saxony—were remarkably rich; hence when their genetic relationships and intimate association with laccolithic bodies of diabase were announced, in 1905,[1] the attention of prospectors was at once directed to every known diabase area in the neighbourhood. This exploratory activity, which attained a maximum vigour in 1909, has continued up to the present time, and new discoveries have been made at numerous points within an area of 1,500 square miles: extending from Lake Timiskaming completely across the district of Nipissing. Prior to the first silver discoveries this area had received little attention, and little exact information regarding it was available when the prospecting campaign began. It was, therefore, necessary for the Ontario Bureau of Mines, and the Geological Survey, to commence mapping it in considerable detail; especially where large bodies of diabase or actual mineral occurrences rendered it economically interesting.

The following description and accompanying map deal with a part of the silver-bearing area which, together with adjacent territory, has been under examination by the writer and his assistants

[1]W. G. Miller, Bureau of Mines Report for Ontario, 1905, Pt. II.

since 1908. This part forms a rectangle 42 miles by 25½ miles, lying in the western part of the district of Nipissing, Ontario, almost due west of Lake Timiskaming. Its western edge coincides with the boundary between Nipissing and Sudbury districts. The greater part of it is contained within the recently created Gowganda Mining Division; although it extends into the adjoining Montreal River Mining Division to the east. Considered with reference to geographical features, it belongs to the upper part of Montreal River drainage basin, to which the name, 'Montreal River District,' is commonly applied.

Acknowledgments.

By arrangement with the Ontario Bureau of Mines, the exploratory work done by Messrs. Knight, Burrows, Rogers, and Bowen was made use of in the compilation of the accompanying map; while at various times, other information, and laboratory materials, were obtained through the courtesy of these gentlemen and of Messrs. Sheppard and Browning, Mining Recorders at Gowganda an Elk Lake. A large part of the field work done for the Geological Survey was performed by the various assistants who were with me during the three seasons spent in Gowganda district. Field work was materially forwarded also by the unfailing courtesy and interest of mine officials and others.

In the preparation of the present memoir, the writer has profited by the friendly and experienced advice of Prof. Leith and others of the Department of Geology, University of Wisconsin.

History of Exploration.

The earliest important explorations in Montreal River district were made in 1866 and 1867 by Messrs. Duncan Sinclair and A. G. Forrest. The Provincial government seems to have been seeking a railway or wagon route to the west, and, acting under their instructions, Sinclair ran a chain and transit line from a point on Montreal river below the Forks for 105 miles westward, intending to connect this with a similar line that was being surveyed eastward from Michipicoten, on Lake Superior, by Messrs. Slater and Gilmour. However, the expected junction was never effected. During the same period Forrest traversed with chain and transit the whole length of Montreal river and the greater part of its east

and west branches. Practically no further exact information was obtained until, thirty years after, Alexander Niven surveyed the boundary between Nipissing and Sudbury districts. Since then, progress has been steady. Beginning in 1903 with James and Barber, an increasing number of townships have been laid out from year to year, until in 1910 the area was completely subdivided. Topographical details relating principally to the waterways have been rapidly collected since 1906, simultaneously with geological explorations.

Until three years ago geological investigation of the district was of an exploratory character only. In 1887, Dr. Robert Bell,[1] in the course of an extensive reconnaissance, traversed most of the Montreal River waters, taking note of the rocks seen on the way. His account contains good descriptions of the various Huronian and Laurentian types, though these terms were applied somewhat differently then than now. Ten years later, Dr. A. E. Barlow[2] visited the outskirts of the district while exploring the country farther south and east. As, however, neither Bell's nor Barlow's visits were more than incidental to other operations, the published accounts do not deal exhaustively with the small area under present consideration. More systematic treatment, resulting in a geological map, was given during 1897 by E. M. Burwash,[3] whom the Ontario Bureau of Mines employed to study the geology along the Sudbury-Nipissing line while it was being surveyed. In addition to a narrow strip along the line, Mr. Burwash mapped and described the country near Pigeon lake, part of Grassy river, and Sinclair's line from its intersection with the district boundary as far east as Mount Sinclair. In 1900, J. R. L. Parsons,[4] geologist to party No. 3 of the ten expeditions sent out in that year by the Ontario Department of Crown Lands, traversed the head-waters of Montreal river. His geological observations are recorded upon an 8 mile to 1 inch map subsequently published by that department.

During the years occupied by these operations there had been no incentive to the prospector to give his attention to Montreal River district. It presented a geological aspect like that of thousands of square miles of neighbouring country. But, with the

[1]Robert Bell, Report of Progress, Geol. Surv., Canada, 1875-6.
[2]A. E. Barlow, Annual Rept. Geol. Surv., Canada, vol X, part I, 1897.
[3]E. M. Burwash, Ann. Rept. Bureau of Mines (Ontario), 1896.
[4]J. R. L. Parsons, Rept. of Surveys and Explorations of Northern Ontario, 1900

publication of the provincial geologist's report in 1905, the relations of the Cobalt ore deposits to the geological features became generally known, and like conditions were at once sought in neighbouring districts especially towards the west. Montreal River district became the objective of a large body of prospectors. A real incentive to thorough exploration at last existed and the response was immediate. C. W. Knight[1] was first in the field, exploring for the Bureau of Mines, in 1907, an area of 225 square miles in the townships of James, Tudhope, Barber, Speight, and vicinity. Next year A. G. Burrows[2] continued work of the same nature around Miller and Bloom lakes, while, for the Geological Survey the writer began work between the East branch of Montreal river and the Algoma-Nipissing boundary. A preliminary report[3] upon this work was issued during the following winter. In 1909, Mr. Burrows extended his work of the preceding year over the townships of Haultain, Morel, Charters, Leith, Milner, and Van Hise. The writer's party gave their attention at the same time to the intervening unexplored areas, chiefly to that between the East branch and Mr. Knight's work of 1907, so as to consolidate the work, which had been confined to isolated areas which were deemed of most importance. In 1910 a brief portion of the field season was spent in Raymond, Corkill, and Leonard townships, securing supplementary information required to present the accompanying map in its existing form.

Topographical work and geological work were carried on at the same time. All lakes and streams that could be travelled in canoes were surveyed with a Rochon micrometer telescope and prismatic compass. Remote ponds were measured and located by rapid chain and compass traverses through the woods or their positions were fixed by the lines to the network of surveyed claim lines which are to be found in mineralized localities. A few conspicuous hills were fixed by triangulation.

Advantage was taken of the sluggish character of Montreal river and its tributaries to determine water elevations in various parts of the district. All these streams consist of lake expansions and sluggish reaches, that fall from one to another by short rapids

[1]C. W. Knight, Ann. Rept. Bureau of Mines (Ontario), Pt. II, 1907.
[2]A. G. Burrows, Ann. Rept. Bureau of Mines (Ontario), Pt. II, 1908.
[3]W. H. Collins, Preliminary Rept. on Gowganda Mining Division, 1908.

or falls, so that almost the entire descent is accomplished in a series of abrupt steps. If the heights of all the rapids and cascades on such a stream be carefully taken and an estimate for the trifling intervening grade be added, the sum is a close approximation to the whole descent. Making use of this method, hand level measurements of the heights of rapids and falls, supplemented by estimates for the intervals of quiet water, were begun at the railway near Latchford, carried up Montreal and Lady Evelyn rivers, across the divide to Smoothwater lake, down the East branch of Nest lake, and thence via the Stony Creek canoe route to Montreal river and back to Latchford, making a complete circuit, the closing error of which was about 5 feet. The corrected elevations so determined may be considered, therefore, tolerably accurate. The elevations obtained in this circuit were used as data for the calculation of other barometric determinations.

Geological boundaries and exposures inland from the surveyed water routes were fixed by chaining or pacing or by means of surveyed claim lines. Rocks are so abundantly exposed that the areas differentiated upon the accompanying map are delimited with considerable exactness. Examination of ore-bearing veins of the district was facilitated during 1909 and 1910 by the rapid progress which had been made in mining.

Development of Mineral Resources.

Extension of the silver-bearing area in Nipissing district has been an important feature in the mining development of Ontario during the last five years. The intimate relation between the silver-cobalt veins and the diabase intrusions was inferred early in the development of Cobalt camp, and this knowledge was applied, tentatively at first, in the exploration of the diabase formation wherever it was known to occur. Expectations were sustained first by discoveries made in the country near Cobalt. A little later part of the army of prospectors attracted to Cobalt moved up Montreal and Lady Evelyn rivers, with the result that in August, 1906, the White and Darby properties at Maple mountain were found. Somewhat later in the summer, silver was reported from James township. The excitement aroused by the original finds was revived, and during the winter and spring of 1907 the neighbourhood of Elk lake filled rapidly with prospectors. From there, search for the favourable

diabase extended eventually to Bloom lake, where cobalt ores were found, and then southward along the diabase to Miller lake where, early in 1908, rich silver-bearing veins were discovered.

In August of that year valuable ore was found on the surface of the Mann and Reeve-Dobie properties, in the adjoining Gowganda district. The spectacular character of samples that were exhibited at the Elk Lake recording office in September caused another 'rush.' As means of communication were very imperfect, the excitement did not reach outside points until the beginning of winter, but when it did, the movement assumed larger proportions. Before spring there were several thousand men in the country around Gowganda lake, and, although deeply snow covered, it was quickly staked off into mineral claims.

A large number of prospectors whose arrival was deferred until spring, finding Gowganda district already occupied, turned to the neighbouring country for prospecting ground—spread, in fact, over a very large area, in which exploration was again rewarded before the end of the summer. Late in June silver was discovered near Flanagan lake, in the southeastern part of Leith township. Since then other discoveries have been made in the neighbouring township of Donovan, just to the south. The expansive movement reached as far as Shiningtree district in Leonard township, so called after Shiningtree lake, near which it lies. Here also silver-cobalt veins of the Cobalt and Gowganda type were found. The first native silver in this district is reported to have been found as early as May, 1909, by Mr. Thomas Saville, but the showing at the surface was not rich enough to attract much attention. However, prospecting was continued perseveringly, with steadily improving results. When the district was examined in September, 1910, veins mineralized with smaltite and niccolite had been found on five different properties, while upon one, known as the Neelands claim, considerable native silver was also visible.

Considering the distance of the Montreal silver field from a railway, developmental mining operations followed prospecting with surprising quickness. The first work was done at Maple mountain in 1908. Machinery was hurried to Elk lake, Silver lake, Gowganda, and Miller lake during the winter months of 1909, and, with the arrival of spring, underground work was begun at each of these centres. There are now eight mines equipped with serviceable machinery in the Elk Lake and Silver Lake area, three at Miller

lake, four at Gowganda, and one at Maple mountain. Owing to work having commenced in these camps at practically the same time, and from the similarity of their physical conditions, the amount of development in each has been nearly the same. The deepest shafts are down from 100 to 180 feet, and the drifts, in every case at a single level, aggregate in some instances 700 feet in length. Previous to October, 1910, an aggregate of 415 tons of ore had been shipped from Miller lake and Gowganda, and 7 tons from Maple mountain. All of this was high grade ore, since, until very recently, transportation was too costly and slow for the economical handling of low grade ore.

Transportation.

Improvement of facilities for transportation has kept pace remarkably well with the needs of the district. In [illegible]. the country was accessible only by canoe or by walking from some convenient point on the Timiskaming and Northern Ontario railway. The routes were necessarily circuitous and from two days to a week were occupied in reaching such points as Gowganda or Wapus creek. The first noteworthy improvement was made in 1907, when small steamers were placed on Montreal river between Latchford and Elk lake. Except for three short rapids, the whole navigated distance of 56 miles is sluggish and deep, hence by placing a vessel on each of the four navigable reaches and tramways across the portages, daily connexions were established between these termini. Since then other lines have been put in operation, and the old service improved. It is now proposed to eliminate Pork rapid, the first obstruction, by damming the river at Latchford, thereby obtaining a continuously navigable distance of 35 miles and at the same time securing a valuable water-power.

Elk Lake, the up-river terminus of this line, created by the mineral discoveries of 1906 and 1907, has become in three years a village of about 300 people. Connected by road with Charlton and Gowganda, it now forms a distributing point to the mines in the neighbourhood and contains the recording office for Montreal River mining division.

With the sudden development of Miller Lake and Gowganda camps, a second business centre sprang into existence at the northeast corner of Gowganda lake. In spite of appearances, that testify

too candidly to hasty growth, the village of Gowganda makes an efficient headquarters for Gowganda Mining Division. The hurriedly constructed sleigh roads that connected it with Elk Lake and Sellwood during the winter of 1909 have been relocated or improved. During the summer a graded wagon road, 27 miles long, was built by the Ontario government from Elk Lake to Gowganda. Meanwhile the Canadian Northern Ontario railway has been extended 31 miles northwestward from Sellwood to Oshawong lake (Gowganda Junction), and a new winter road, 45 miles long, has been cut from the Junction to Gowganda. At present either Elk Lake or Gowganda may be reached in one day's railway and stage travel from important points in Ontario. Both places have telephone connexion, a daily postal service, mining recorder's offices, and banks.

Maple Mountain camp, which lies well away from the other mining centres, has been connected by road with Latchford.

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SUMMARY.

Gowganda Mining Division forms part of the great Pre-Cambrian peneplain of northern Canada. It is essentially a hummocky and rocky plain, elevated 1,000 feet above sea-level. In all parts of it rocky hills with rounded outlines, typical of glaciation, and asymmetrical ridges rise from 100 to 900 feet above the general level. A soil-sheet of glacial materials—chiefly sand and gravel—buries the rock surface in a few localities and effectually softens its ruggedness. Small lakes occupying irregular, rocky basins are remarkably numerous. Except where recent fires have occurred, the whole country is clothed with dense evergreen forests.

All the rocks in the district are Pre-Cambrian. The oldest form a highly crystalline peneplanated basement that everywhere underlies the younger formations, or where the latter have been eroded, appears at the surface. This basement consists, in the western half of the area, of highly metamorphosed, steeply inclined, Keewatin schists, mostly of igneous origin; and in the eastern part, of Laurentian granites and gneisses. Where areas of the crystalline basement many times larger than the present one are considered, the Keewatin schists are found to occur as great irregular or elongated patches, sometimes wholly surrounded by Laurentian, but always showing a tendency to be connected together to form a great network. Such patches are thought to be synclinal parts of great folds developed in a once more continuous Keewatin formation by upward batholithic intrusion of Laurentian granitic matter. Subsequent erosion has removed all the Keewatin except these infolded parts and laid bare the upper parts of the intrusive batholiths. The Keewatin in the western half of Gowganda district is part of such a synclinal patch, and the granites in the eastern half are part of a Laurentian batholith. The intense metamorphism which parts of the Keewatin have undergone antedates the overlying Huronian sediments, and appears to have been effected by Laurentian intrusions. The original extrusive and intrusive igneous rocks and the subordinate

amounts of sediments composing the Keewatin are well preserved in the extreme western part of Gowganda district, but, nearer the Laurentian, they have been altered across a zone 5 or more miles wide into steeply inclined, fissile schists largely of chloritic nature. In more immediate proximity to the granite these have been further altered to crystalline hornblende schists.

The crystalline basement is exposed over only about one-fourth of the mapped area; elsewhere it is overlain, in striking unconformity, by a gently folded and but slightly metamorphosed mantle of Huronian clastic sediments. An inconspicuous unconformity separates this mantle into a lower and an upper series. The lower series consists of conglomerate, greywacke, slate, and arkose. Conglomerate is, seemingly, a constant basal member; otherwise there appears to be no definite order of succession. In the extreme southwestern part of the district an extrusion of rhyolite and rhyolitic tuff is associated with these sediments. The whole series is at least 500 feet thick in many places and possibly 1,000, but a few localities are known where it is missing and the upper series rests directly upon the old basement: hence its thickness is in all likelihood very variable.

Imperfect bedding, poor assortment, local variations in the order of succession, and other peculiarities are taken to indicate terrestrial or shallow water deposition; certain features in the slate member imply transportation by ice, and the till-like character of the conglomerate has been interpreted by one authority as indicating glaciation.[1]

The upper series consists of a single quartzite formation, 600 feet or more in thickness. It ranges from arkose to very pure quartzite or chert. Thin interbedded lenses of conglomerate, distinguished by an abundance of quartz pebbles, recur frequently, and a conglomerate or breccia a few feet thick has been found at the base. Especially in the southern part of Gowganda district, where it is well assorted, bedded, and ripple marked, the quartzite appears to be a normal subaqueous deposit. Upper and lower series lie in the same gently folded attitude.

In post-Huronian, possibly Keweenawan time the crystalline basement and mantle of Huronian sediments were intruded by diabase, which formed dykes and sills. As a rule the dykes do not

[1]A. P. Coleman, The Lower Huronian Ice Age, Jour. Geology, Vol. XVI.

exceed 100 feet in width; the sills attain thicknesses up to 500 feet or more and are many square miles in horizontal extent. The former are vertical, very numerous, and in far greater abundance in the crystalline basement than in the Huronian formation. The sills, on the contrary, are found only within the Huronian, along the bedding planes of which they were injected or immediately beneath it. Where cooling was slow enough, the magma forming these large bodies obeyed imperfectly a tendency to differentiate into two parts: a principal one of ordinary diabase, and a subordinate one of aplitic nature. The aplite occurs as dykes and irregular segregations within the diabase. It is probable that a micrographic intergrowth of quartz and plagioclase occurring in coarse-grained phases of the diabase also represents aplite in an incipient stage of differentiation. The older rocks adjacent to the sills have been altered for distances seldom exceeding a yard. No perceptible change of this nature has taken place in Laurentian or Keewatin rocks. Of the Huronian sediments, quartzite has been rendered hard and glassy looking by recrystallization, and for a thickness of a few inches at the immediate contact, fused to a dark slaty looking material. Greywacke has been changed to a form of adinole or rarely to a reddish crystalline material resembling certain aspects of the aplite that accompanies sill diabase.

Intrusion took place tranquilly, and was followed by slight faulting of the older rocks and of the diabase itself. It was also succeeded by a period of mineralization when quartz-calcite veins bearing sulphides, arsenides, sulpharsenides, and sulphantimonides of cobalt, nickel, silver and copper, and native silver were deposited within or in close proximity to diabase sills. Quartz and at least a portion of the ores were derived from the diabase magma, presumably in the form of an aqueous, residual solution. The calcite gangue may have had the same origin.

Dykes of olivine diabase were intruded after the quartz diabase bodies had solidified.

The present glaciated surface of these Pre-Cambrian rocks is covered thinly and discontinuously by glacial gravels and sands, of Pleistocene age.

Economically, Montreal River district is chiefly important for its silver-cobalt ore deposits, that accompany quartz-diabase sills. The first of these were discovered in 1906, and since then mining operations have been commenced in five different localities: Elk

Lake, Silver Lake, Miller Lake, Gowganda, and Maple Mountain camps. The deposits in each case are similar in most respects to those in the neighbouring Cobalt districts. They form veins, commonly less than a foot wide, either within the diabase or, in a few cases, in the formations immediately adjacent. These consist of a quartz and calcite, less frequently barite, gangue carrying native silver, smaltite, niccolite, chalcopyrite, and smaller amounts of native bismuth, argentite, galena, pyrite, specularite, and other minerals. Silver was deposited somewhat later than the other minerals and traverses them as a fine network. Erythrite and annabergite occur as oxidation products of smaltite and niccolite for a depth of a few feet beneath the surface. The ores are not evenly distributed through the veins, but occur, so far as present explorations indicate, in irregular masses. The diabase, for a few inches away from the veins, is often irregularly mineralized.

Iron ore is now being sought for in the Keewatin iron formation, which occurs at several points in the southwest corner of the area. Exploratory work, consisting of surface stripping and test pitting, is in progress in the most promising area, near the middle of Leonard township. The ore bodies have slender lenticular outcrops and appear to descend nearly vertically. The surface ore itself is a siliceous mixture of magnetite and hematite of low grade.

Small seams of asbestos, accompanying olivine bearing intrusive bodies, are found at several points in the Keewatin. None of these, within the present area, are commercially valuable, but near Mount Sinclair, 10 miles north of it, the asbestos is said to be of good quality and perhaps in workable quantities.

GENERAL CHARACTER OF DISTRICT.

Topography.

Montreal River district belongs to the great region of crystalline Pre-Cambrian rocks to which Suess has given the name 'Canadian Shield.' It presents the same general flatness and evidences of peneplanation that characterize the larger region, although when so small an area is considered, this flatness is veiled by locally harsh topographic details. For the greater part it consists of rough hills, 100 to 300 feet high, and often faced on one side by sheer escarpments. The solid rock composing them, if not actually visible,

can generally be exposed by scraping away a few inches of moss and forest mould. The lower ground between the hills is better provided with soil; taking the form of a swamp or flat muskeg, or, occasionally, of a sandy tract. Some of the sandy areas extend over several square miles or even cover whole townships, and in such places the country becomes gently rolling, but few of the muskegs and swamps exceed a few hundred yards in width. Rock-bound lakes and streams are numerous. Equally striking are occasional isolated hills and ridges that rise conspicuously above the general level of the country. Knob-shaped masses of this sort are especially frequent in the northwestern part of the area. From the tops of these commanding masses the real peneplain nature of the country is apparent. Instead of the harsh, rocky details so impressive at close range, there is presented an undulating wooded country which, toward the horizon, from 3 to 15 miles distant, grows comparatively level. The flatness of the district as a whole is reflected in the drainage system. Lake levels at Latchford and Gowganda, 50 miles apart, are 905 and 1,099 feet above sea-level, respectively. Duncan lake is about 75 feet lower than Gowganda and 10 miles distant; Nest lake, 15 miles away, is 94 feet lower. In spite of the rugged topographical details, the average slope is, therefore, not greater than that of a rolling plain.

INFLUENCE OF GEOLOGICAL STRUCTURE.

The superficial relief is essentially carved in solid Pre-Cambrian rocks, and its dominant glacial character is strongly modified by their structural characters. This influence of geological structure upon erosional sculpture, though everywhere effective, is most noticeable in Huronian sedimentary formations. When crossing a Huronian area, as for example in going from Duncan lake to the West branch, or along the south boundary of Shillington township, a succession of asymmetrical, north and south ridges are encountered whose western sides are rocky and precipitous, while the eastern sides form gentle, forested slopes. These ridges follow one another with great regularity, the intervening valleys being narrow and swampy or containing creeks. The West branch, for a few miles northward from where it receives Wapus creek, occupies such a through, whose lack of symmetry is well shown by the abrupt eastern and shelving western banks of the river. Ridges of this

sort are simply inclined masses of Huronian strata whose dip coincides with and determines the easier slope, the steep slope showing the same beds in the cross-section. A succession of such monoclinal blocks is similar in arrangement to the overlapping shingles of a roof.

Nearly all the prominent hills have this structure. Maple mountain, much the largest among them, is a huge ridge that extends for 12 miles north and south through Whitson and Rorke townships, and rises 950 to 1,000 feet above Anvil lake. The strata forming it dip about 25° W., hence that side of the great ridge is the gentler one. Burwash describes Mount Sinclair as a ridge 1,000 feet high, extending north and south and terminating southward in an escarpment. A conspicuous ridge of the same kind at the north end of Duncan lake is 400 feet high and continues northeastward for several miles. Its western face is rocky and perpendicular in places while the eastern slope does not exceed 18 degrees, thus agreeing in inclination with the underlying Huronian beds. From its highest point nearly one-fourth of the area represented on the

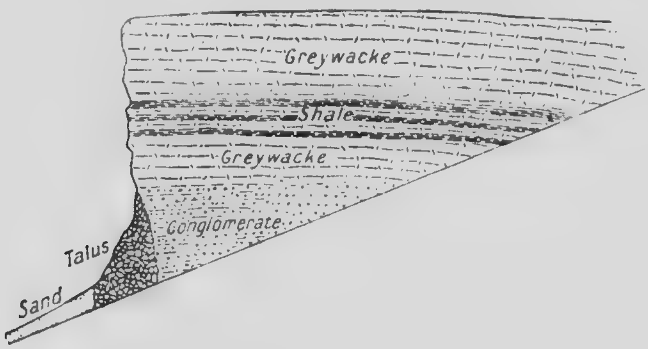

Fig. 1. Vertical section across Huronian ridge, north of Duncan lake.

accompanying map is visible, an unusual number of great flat-topped hills, including Mount Sinclair, appearing to the northwest.

The diabase sills—great tabular bodies miles in width and several hundred feet thick—which lie interbedded with the Huronian, have also exerted an important influence upon the configuration of the surface. The diabase resists erosion better than the sedimentaries, and is usually left standing high. In Willet town-

ship and northward, where it lies nearly flat, the sill has been worn into irregular hills in places made up of a thick cap of diabase upheld by a broad quartzite base. Elsewhere the sills are more or less tilted, so that an edge instead of a broad surface protrudes, and ridges are produced. These ridges are accentuated by marginal trenches carved in the Huronian, which, at its contact with the diabase, is shattered and easily eroded. The small ponds and creeks so often found along the diabase-Huronian contact are contained in such lateral trenches. The lower third of Duncan lake lies in one, and the narrow bays that project northward and southward from its median expansion are accommodated in like manner. Gowganda lake expresses this habit even better and in various degrees of perfection. Its northwest and northeast arms lie continuously along the sides of a diabase strip. On the shore of the main lake, west of the large island, are three small land-locked bays, elongated in linear fashion along the contact between diabase and Huronian in a manner that indicates unmistakably a tendency to form a third slender arm more or less parallel to the other two.

FAULTING.

The lakes and streams reveal very clearly another peculiarity, otherwise not readily perceptible. A little consideration of the map shows that many of these occupy notably straight depressions; further, that they may be resolved into two well defined systems, intersecting at right angles. The majority are aligned in a nearly north and south direction. A smaller number show a parallel east and west arrangement. For example, the West branch, from its junction with Wapus creek runs northward for 4 miles, then turns sharply towards the east for 2 miles, after which it returns with equal abruptness to the original direction. Just above Mistinikon lake it again deviates in this angular manner, while, a few miles to the east, the same rectangular bends are repeated in Zigzag lake. The East branch exhibits the same peculiarity; sharp turns are observable on Burke and Obushkong lakes, and below Obushkong lake it is deflected sharply to the east for 3 miles almost in direct line with the similar eastward bend on the West branch. The elbow shapes of Crane and Foot lakes illustrate the same tendency in other parts of the area.

These intersecting systems are observable over a considerable part of Nipissing district, although the directions vary locally. In his account of Cobalt district, Miller[1] describes striking instances in the country west of Lake Timiskaming, and concludes that they indicate either folding or regional faulting, the evidence at Cobalt favouring the latter alternative. In Montreal River district the north and south system coincides with the axial direction of folding The conditions at Mistinikon lake, however, are rather suggestive of faulting. This lake is a narrow, straight body whose shores rise often precipitously. The western shore is entirely Huronian, and the eastern entirely Laurentian or Keewatin. The contrast in this respect is particularly evident in a narrow ravine that extends southward from the little bay in the southeastern angle of the lake, for although the ravine is only a few chains in width at the bottom, the sides, consisting of gneiss on the east and flat-lying greywacke on the west, are 150 feet high. It is not easy to explain either the cleft or the sudden disappearance of the Laurentian gneiss west of it except by considering it to coincide with a fault plane.

The east and west system lies at right angles to the axial direction of folding, and in numerous instances is related to dislocations. Those portions of Zigzag lake which extend from east to west are enclosed by perpendicular walls of gneiss, clearly not produced by erosion. Again, the Huronian strata forming the shores of the West branch, where it runs eastward across the Knight-VanHise boundary, are sheared, steeply tilted, and strike parallel to the river; while immediately to the south they have a gentle easterly dip, general for that portion of the district. These conditions certainly imply differential movement in a narrow east-west zone, with some vertical displacement.

INFLUENCE OF THE SOIL SHEET.

The soil sheet, consisting largely of glacial sand and gravel with a thin cover of vegetable mould, varies in depth in different parts of the area, and consequently masks in varying degree the topography of the underlying rock surface. Where it is deep enough to entirely conceal the rock basement, the country assumes a gently undulating or even flat appearance, strikingly unlike the precipitous and hummocky forms that characterize the solid rock surface.

[1] W. G. Miller, Bureau of Mines Report (Ontario), 1905, Pt. II.

This contrast can be well seen from the top of the Huronian ridge that rises at the north end of Duncan lake; from that elevation a flat sand plain, several square miles in extent, is visible to the west and southwest, and beyond it a succession of monadnock-like rocky hills from 200 to 500 feet high. Similar level sand plains occur east of Cap lake in Morel township, in the northern part of Farr township, and, on a somewhat larger scale, in Corkill and Lawson townships.

In Lawson and Chown, also in southern Leonard, where the glacial sand is at least 100 feet deep, the surface is irregularly undulating, and frequently pitted with steep-sided kettle-holes that are believed to have originated by the melting of huge blocks of glacial ice. Most of these kettles are dry; a few contain small ponds without visible outlets. Wherever streams traverse these areas they cut canyon-like channels like that of Montreal river below Indian chute. Original esker ridges of small size are well preserved in southern Shillington and in Corkill townships.

In localities poorly covered with soil muskegs are characteristic features, though they are seldom extensive. They are underlain, superficially, by wet, black mould, and have resulted in many instances at least from the silting up of lake basins. Frequently a vestige of the original lake persists in the form of a shallow, muddy pond enclosed by muskeg. Owing to the manner in which muskegs grow, their surfaces are almost as level as the original lake surface and seldom more than a few feet higher.

Drainage.

Like other parts of the Pre-Cambrian region, Montreal River district appears to contain an enormous quantity of dormant water, that is, water waiting removal. It is collected into lakes, often of large size and numerous enough to provide canoe routes to all parts of the district. But this apparent abundance of water does not indicate a correspondingly great precipitation, for the thick soil sheet, that in most regions takes up and conceals rainfall after the manner of a sponge, is here very sparingly and locally distributed. Consequently, over most of the district water lies exposed in the depressions of a nearly bare, impermeable surface. Hundreds of lakes are the result. Streams fed by the overflow from such bodies

have to find their way across the uneven rock floor by employing as channels any convenient inequality, and consequently lack the uniformity of ordinary streams. As a rule they are simply successions of lake expansions, exceedingly diverse in shape and size, which alternate with brief constrictions where rapids and cascades are usually to be found.

In places where the rock floor is well buried beneath glacial debris, more normal drainage conditions prevail. Lakes are less frequent, and the streams develop meandering channels of uniform width and grade, thereby eliminating lake expansions and falls to a large degree. Springs become an important source of supply for the smaller brooks and creeks.

Naturally, where the soil sheet thins out there is a transition from one set of conditions to the other.

Lakes that receive a small inflow contain remarkably clear water. Elsewhere it is coloured brown by organic matter, especially in creeks issuing from swamps, which are more deeply coloured than the larger streams. Exceedingly little solid matter is transported; the available supply, limited very largely to glacial deposits, is small. Even what can be obtained is soon dropped in the lake expansions that serve as settling basins. A striking instance of this behaviour is exhibited on the East branch, near the south boundary of Morel township, where a small creek entering on the west side, has built with its alluvium a tongue-shaped delta half way across the larger stream, the latter not having sufficient current to carry off this exceedingly fine mud.

As implied by its name, Montreal River district is drained by this one river. From near Fort Matachewan the main stream pursues a direct southeasterly course to Latchford, then deviates at right angles for a few miles and again returns to the original direction, which it maintains to Lake Timiskaming. The minor deviations near Indian chute and Mountain lake are not important. In the latter case it is not easy to understand why the direct course is not maintained, since the obstruction met with there seems very slight to divert even the enfeebled current that issues from Mountain lake. From the Forks down to the entrance of Sydney creek the course is swift, winding, and broken by slight rapids; but from there onward it winds tranquilly through a clay or sand filled valley. The underlying rock floor forms an obstruction only at Indian chute, where the river tumbles 23 feet over a ledge of gneiss.

Mountain chute, Flat rapids, and Pork rapids appear to be caused by boulder accumulations.

The remarkably straight channel from Latchford, up-stream, separates two drainage areas of very unlike character. On the northeast is a soil covered country, possessing numerous winding creeks, but only a few small ponds; southwestward the country is bold, rocky, and thickly dotted with lakes. From the northeast, Montreal river receives a few insignificant brooks; from the southwest come all its important tributaries: Lady Evelyn river, Spring, Bear, and Sydney creeks, and East and West branches.

Brief consideration of the map will show each of these large feeders, with local exceptions, to be typical of the rocky peneplain they traverse. Each is a chain of lake expansions, highly irregular in outline, that overflow from one to another through constricted channels, full of rapids and falls. The West branch is the largest, having a somewhat greater volume than the East branch. Its main gathering ground lies in Algoma, for it is a large stream where it enters Pigeon lake, but important additions are received from Wapus creek and Duncan lake. The brook that enters at the north end of Duncan lake pursues a swift, meandering course through a sand plain from which it transports and deposits at its mouth large quantities of sand. Though of considerable volume it cannot be navigated. Wapus creek, on the contrary, is a broad, sluggish stream as far up as the fall near the Tyrrell-Leonard township line. Farther up it is filled with logs, and scarcely navigable. At its extreme northern point—Great Northern bend—the West branch cascades 40 feet downward into Matachewan lake.

The East branch virtually originates in Smoothwater lake, a fine body of much clearer water than any to be seen farther downstream. Most of the way from Smoothwater to Gowganda the river winds tortuously through swamp, but the remainder of its course, except for one mile of swift water at its mouth, is a chain of expansions. It receives only one feeder of importance—a large brook from Hangingstone lake.

Sydney creek is smaller than the East branch but is similar in form. It is largely fed by springs. One tributary creek that enters the eastern bay of Long Point lake is almost wholly supplied by springs, the largest of which will float a canoe. The Calcite Creek branch is largely maintained in the same way: it receives one brook

which issues as a spring directly from beneath a gravel ridge in the northwestern corner of Corkill township. The various feeders of the north branch of Bear creek are meandering creeks, but the south branch consists of the usual lake expansions and falls. Bear lakes, in which the south branch rises, possess the same limpidity as Smoothwater. Spring creek is of insignificant volume, but affords a convenient route to Maple Mountain district.

Lady Evelyn river, which is next in size to the East branch, is chiefly notable for its large lakes and unusually numerous and high falls. Helen fall is 80 feet high. In McGiffin township the river divides into two nearly equal branches, both of which are navigable to their sources.

Montreal river is navigated by small steamers as far up-stream as Indian chute, but the higher waters are practicable only for canoes and launches. The country away from the chief tributaries is rendered accessible by the sluggish, naturally dammed character of the small affluents. Sometimes an insignificant trickle of water—for example, the creek from Zigzag lake—affords a good canoe route for miles. The numerous falls and rapids on all the larger streams afford good water-power, those at Indian chute, Great Northern bend, Helen, and Mattawapika falls being especially large. Montreal river is well adapted for the transport of logs—lumbering ranks at least next to mining in potential importance—but the tributaries are practically useless for this purpose.

Forests.

Fire-swept areas and muskegs excepted, the whole country is forested with evergreens and, subordinately, deciduous trees. The prevailing scarcity of soil seems less deterrent to tree growth than excessive moisture, for a virtually bare rock surface will support jackpines and spruces of moderate size, but muskegs are either treeless or very sparsely clothed with stunted spruce and tamarack—the only species which seems able to exist in such places. The most valuable forest grows in sandy districts, like Chown and Mickle townships, but dense growths occur in all parts of the country where a few feet of soil exists, especially near watercourses.

White pine is the most valuable tree, but, although individuals attain thicknesses of 20 to 40 inches, they are too scattered to be worth the search. The red species is much more abundant. It is

best developed in the sandy parts of Chown, Mickle, James, and adjoining townships, often forming extensive forests, in which individual trees grow tall and 8 to 20 inches in diameter. The Gowganda-Elk Lake wagon road goes through the best parts of this area. Jackpine and spruce occur nearly everywhere; cedar, tamarack, and balsam are more restricted and nowhere very abundant. Poplar, white birch, and yellow birch are the common deciduous trees, being scattered over the whole district, and a few hard maples are to be found in places. Maple mountain is said to derive its name from specimens of this tree being found growing upon it, and several beautiful groves were seen to the southwest of Pigeon lake.

A large lumber camp operated by the Booth Lumber Company of Ottawa is now established at Elk Lake, a short distance above the village, and lumbering operations are under way along the east side of the river as far up as Indian chute. The country to the west, however, forms part of Timagami forest reserve. During the summer months it is guarded by a staff of fire rangers, in spite of whose vigilance, however, large areas have been devastated by fire since the recent advent of prospectors. Parts of the country near Miller, Gowganda, and Nest lakes are now so encumbered by fallen, partly burned trees that progress through it is most difficult. A splendid forest of red pine near Long Point lake was killed by a fire that swept through it in June, 1909, leaving the trees standing leafless. Within six weeks it was so infested by boring insects that at any time in the day a fine sawdust could be seen falling through the air, accompanied by a distinctly audible gnawing sound from the insects at work. The timber destroyed in this locality alone exceeds in amount all that has been used in the entire district.

Wild animals are still fairly plentiful. Moose, Virginia deer, and an occasional black bear were met by members of our party. Beaver dams are quite common, but the animals themselves seldom appear during the day. As a source of food the abundance of pike and pickerel is of greatest importance. Lake trout are taken in Bear lakes, Smoothwater, and some of the lakes near Mount Sinclair.

GENERAL GEOLOGY.

General Outline.

There are two striking unconformities in the geological record of Gowganda district that imply at least two great periods in its history during which its surface was subjected to erosion. The rocks above and below these unconformities are so unlike in appearance, owing both to original differences and to subsequent metamorphism of different intensity, that they naturally constitute three distinct structural and lithological elements. Once this three-fold subdivision is perceived, the geological problem loses much of its apparent complexity. As represented in the accompanying diagram, the lowermost and oldest element is an uneven basement made up essentially of igneous crystalline rocks. Upon its deeply worn surface reposes a thick mantle of sedim[illegible] whose well preserved stratification and clastic textures cont[illegible] strongly with the highly developed metamorphic features of the older group. And upon a similarly eroded surface of this mantle, in turn, lies a thin film of sand and gravel not yet consolidated and bearing plentiful evidence of a glacial origin. In the ordinary sense sand and gravel are considered soils rather than rocks, so that from the standpoint of solid geology only the first two of these three elements require consideration. During the second great erosion period a large part of the sedimentary mantle was worn completely through, hence at the present day both [illegible] sement and mantle are visible, the overlying film of glacial debris being too thin at most points to conceal them.

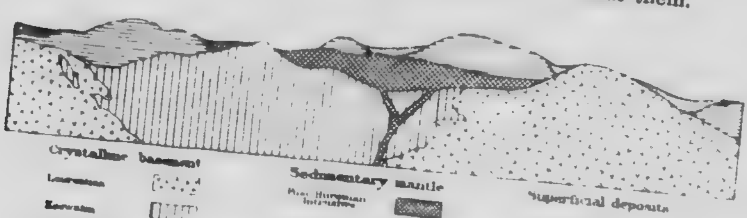

Fig. 2. Diagram representing geological relationships in Gowganda Mining Division.

The basement, which is laid bare over one-fourth of the mapped area, is itself divisible into two distinct parts. One of these (Keewatin) is a complex assemblage of extrusive and intrusive rocks,

together with a minor quantity of sedimentary material; the other (Laurentian) consists exclusively of granitic and gneissic rocks. Keewatin rocks are prevalently fine-grained, schistose, and dark in colour, commonly green, while the Laurentian types are coarse-grained, either massive or gneissic, and grey or reddish. They are, therefore, easily distinguished in the field.

In Gowganda Mining Division too much of the basement is buried under the younger mantle of sediments for the distribution of Keewatin and Laurentian to be everywhere visually determined, but, from what can be seen, the general arrangement is closely similar to that observable in other parts of Ontario where it is more fully exposed. In Lake of the Woods district, for example, the Keewatin forms elongated, ragged patches, either connected with one another so as to resemble a series of gigantic meshes,[1] or separate and surrounded, island-like, by the Laurentian. These patches are edged by a contact zone or aureole of highly crystalline schists. Lawson considers them to be the synclinal parts of folds produced in a formerly more continuous Keewatin formation by uprising batholithic bodies of magma, which on cooling formed the Laurentian. The higher parts of these folds, he believes, have been removed by erosion, which simultaneously exposed great areas of the batholiths.

Visible Keewatin areas, of which there are a number, are confined to the western half of Gowganda district. In the intervals separating these patches the crystalline basement is covered by Huronian strata, and it cannot be visually decided whether, at such concealed points, it is Keewatin or Laurentian. But, when the zone of highly crystalline schists that represents the Keewatin-Laurentian contact is traced out as fully as possible, it curves in a sinuous line, west of which lie all the small Keewatin areas. It is not improbable, therefore, that the latter are only exposed parts of a single large Keewatin area of the sort described by Lawson which underlies the whole western part of the district. The form and full size of this larger area have never been determined, but it certainly extends much beyond the limit of the area here considered. Burwash found it to continue northward along the Algoma-Nipissing boundary for 19 miles beyond the northwest corner of Raymond township before giving place to Laurentian. In a number of places it has been followed west of the same boundary for 5 or 6 miles

[1]A. C. Lawson, Map Accompanying Annual Report, G.S.C., 1887.

without finding a termination. Its southern edge, however, lies only about 5 miles from Shiningtree lake, hence the Keewatin within the limits of the accompanying map may be considered as the south-eastern portion of this great areal and structural unit.

Upon similar grounds the crystalline basement in the eastern half of the district is believed to be wholly Laurentian. Its exposed portions consist essentially of biotite and hornblende granites. The latter is often nearly quartzless, besides being poor in orthoclase, thus becoming a hornblende syenite or granodiorite. There are also dykes of pegmatite and vaguely defined masses of the nature of basic segregations, richer in dark minerals than ordinary granites. More conspicuous than these differences, however, is the degree to which the granites have been foliated. Some parts of the biotite bearing rock especially are quite gneissic. With the Laurentian are also included ribbons and angular blocks of a crystalline, black hornblende schist, which represents Keewatin fragments torn from that formation at the time of Laurentian intrusion, enclosed in the fluid granite, and recrystallized. Successive stages in this process can be seen along the existing Keewatin-Laurentian contacts, where such inclusions are most abundant. Inclusions are not restricted to contact zones, however, for in a number of instances they were found in the gneiss as far as 2 miles away from the nearest Keewatin—vestiges torn from the bottom of the Keewatin formation that once existed in these places.

The sedimentary mantle lying discordantly upon an eroded surface of both Keewatin and Laurentian rocks, consists of bedded clastic materials of Huronian age. These are separated into a lower and an upper series by a faint and seemingly discontinuous unconformity. This unconformity is marked only locally by a few feet of conglomerate or breccia, and the strata above and below it lie in the same attitudes, consequently it is by no means so easily recognized as that between the Huronian and older crystalline rocks, and can scarcely be considered to represent so long a period of time as the latter. The lower series consists basally of conglomerate succeeded above by greywacke, siliceous shale or slate, arkose, and another conglomerate. From the composition of the conglomerate pebbles the materials forming this series appear to have been derived from the underlying Keewatin and Laurentian. In the southwestern part of the area a small amount of rhyolitic lava and coarse tuff lies at the base of the series. The total thick-

ness of a complete section cannot be ascertained. However, partial sections 400 feet thick have been found in cliff faces, so it must exceed this amount.

The upper series consists wholly of quartzose materials—quartzite and arkose with frequent thin bands of quartz conglomerate. It is certainly over 500 feet thick and probably much more. According to Barlow it is 1,100 feet thick in Whitson township, where it forms Maple mountain. But the actual thickness of the two series combined in the present greatly eroded state, probably rarely exceeds 1,000 feet, and an average value for the district is less. Both series have been faulted and thrown into gentle north-south folds, the dips of which increase from 5 to 10 degrees at the eastern side of the area to 30 degrees at the west.

With the Huronian sediments are associated two younger igneous intrusions: an earlier extensive one of quartz diabase, and a later, less important one of olivine diabase. The quartz diabase magma rose through vertical fissures in the crystalline basement now represented by a multitude of diabase dykes. Upon reaching the sedimentary cover, where mechanical conditions were different, the vertical course was abandoned and the fluid diabase spread out either beneath the sediments or between them to form great sill-shaped or laccolithic masses. The intrusion produced remarkably little disturbance in the adjacent strata. While cooling, the magma in the sills differentiated incompletely into a basic diabase and an acid aplite. Aplite is small in amount compared with the diabase which it traverses as small dykes. With the sills are also associated quartz-calcite veins carrying the sulphides and arsenides of cobalt, nickel, silver, and copper that have attracted so much attention to the district. The later intrusion of olivine diabase is represented only by occasional dykes, the larger of which are given a distinctive appearance by huge phenocrysts of labradorite.

As already described, the present rock surface is a glaciated peneplain underlain entirely by Pre-Cambrian rocks and scantily covered with glacial debris. Glacial striæ and boulders are abundant. The gravel and sand exhibit moraines, kettle-holes, and other structures of glacial origin, and are unstratified, except along Montreal river, whose banks, for some miles below Indian chute, consist of finely bedded clay and sand.

Table of Formations.

The chief geological subdivisions may be enumerated as follows:—

Pleistocene			Unconsolidated glacial till, stratified clay and sand.
			Great unconformity.
Pre-Cambrian	Post Huronian intrusions		Olivine diabase. Quartz diabase and aplite.
	Huronian	Upper or Middle	Quartzite, arkose, and quartz conglomerate (Lorrain series).
			Faint unconformity.
		Middle or Lower	Conglomerate, greywacke, slate, and arkose (Cobalt series).
			Rhyolite, lava and tuff.
			Great unconformity.
	Laurentian batholithic intrusions		Hornblende and biotite granites, granodiorite and syenite and their gneissic equivalents.
	Keewatin		Basic and acid volcanic and intrusive rocks, chloritic and sericitic schists, iron formation, graphitic slate and hornblende schist.

Keewatin.

The original eruptive rocks and subordinate amounts of sedimentary matter composing the Keewatin are more or less intensely metamorphosed according to the localities in which they occur. In the townships of Tyrrell, Knight, and Raymond they retain their primary character most perfectly: so perfectly, in fact, that when first examined it was thought possible that they were younger than the schists found elsewhere. With the exception of some local shearing, the Keewatin rocks in these townships are massive. Some of them exhibit ellipsoidal and vesicular structures in excellent preservation; also spherulitic and other delicate, easily destroyed, textural features.

These least disturbed rocks lie toward the centre of the great Keewatin area whose extent and relationship to the Laurentian were discussed earlier. Proceeding outward from this centre, the massive, well preserved types give place to schists, the change being a gradual one so far as can be determined from observation of the discon-

tinuously exposed patches. This is true toward the west and south wherever explorations have been made. Toward the east, that is, within the area dealt with particularly in this report, it is invariably the case. The minor areas in Leonard, Van Hise, and Nicol townships, and near Duncan lake, are all composed of more or less conspicuously fissile schists, either chloritic or sericitic in character. These continue to within a half mile or less of the Laurentian contact, and then become transformed by imperceptible degrees into a more notably crystalline hornblende schist of characteristic glistening black appearance. Hornblende schist extends to the contact, becoming more coarsely crystalline as the contact is approached. The outer portion of this contact zone is fractured and penetrated by stringers of granite, and pieces of it have been torn loose and floated off into the originally fluid Laurentian. At all places where such observations were possible, the strike of the hornblende schists and equally that of the chlorite and sericitic schists, was found to agree in direction with the line of contact. As the latter varies in its course from nearly north-south to east-west, this accordance is significant.

On the basis of metamorphism, therefore, the Keewatin is separable into three rather vaguely defined but lithologically distinct parts:

(1.) An area composed of metamorphosed, essentially massive rocks, which belongs to the interior portion of a major Keewatin area.

(2.) A broad belt of highly foliated metamorphic products distinguished by an abundance of secondary micas, which belongs to the outer portion of the same major area.

(3.) A narrow outermost zone of exceptionally crystalline hornblende schist, resulting from contact action with the Laurentian.

These alterations appear to have been caused by the Laurentian, for they vary in nature and intensity with the distance away from it. The agreement between the direction of schistosity in the schists and the Laurentian contact is scarcely explicable upon any other assumption. And it is further certain that Keewatin metamorphism was accomplished very early, for most or all of the existing rock types occur as pebbles in the Huronian basal conglomerate. Fragments of the hornblende rich contact aureole are enclosed by the Laurentian itself.

Obviously the task of separating and mapping the individual formations of which the Keewatin was originally composed is difficult, if not impossible. For, though the mutual relationships of these formations were sufficiently complex of themselves, they have been further obscured to the point of obliteration by the veil of metamorphic change. From the many distinct rock types recognizable in undisturbed parts of the Keewatin, there result in the schistose zone essentially only two: a chloritic and a sericitic schist. And these, in the more intensely affected contact aureole, are represented almost exclusively by hornblende schist; for though a micaceous schist is also formed, it occurs rarely in the present district. Even the separation of metamorphic types from each other and from the original rocks is unsatisfactory on account of the indefinite, transitional manner by which they give place one to another.

Within the little metamorphosed central core, however, subdivision is entirely feasible. But the number of formations is large, their present areal distribution exceedingly irregular, and the labour involved in a separation correspondingly great and as yet scarcely warranted by economic considerations. Upon the accompanying map, iron formation and asbestos bearing harzburgites of possible economic interest have been indicated separately. The remainder of the complex is left unsubdivided, but, in the description of it which follows, what is known concerning the distribution of its constituent formations is indicated verbally. The order of succession has not been worked out, and is not expressed by the sequence of the descriptions.

ORIGINAL ROCK TYPES.

Hornblende Porphyrite and Associated Phases.—A considerable portion of the township of Tyrrell in the neighbourhood of Mosher, Breese, and Porphyry lakes, also the line of hills extending along the west side of the West branch for a mile above Mosher lake, is underlain by an assemblage of volcanic materials which seem to constitute a related group. The type most frequently seen is an ash-grey porphyritic rock consisting of a dense bluish-grey groundmass in which are embedded abundant stout crystals of white feldspar a fourth of an inch or less in diameter. Intimately associated and apparently in continuity with it is a very fine-grained, grey-

green rock which shows both ellipsoidal and pyroclastic structures. Both types are massive.

The two large hills lying just south and west of Mosher lake are made up largely of the fine-grained variety. An ellipsoidal structure is plainly visible on weathered surfaces, which are marked off into irregularly rounded areas a yard or less in diameter by a network of shallow grooves about an inch wide. The ellipsoids so outlined consist of a massive greyish-green rock about as fine-grained as slate. The surrounding grooves are worn in material of equally fine grain but full of small white spherulitic spots that might be mistaken for feldspar phenocrysts. In the low ground just southwest of these hills, the ellipsoidal structure is more pronounced and the spotted marginal portions form bands 6 inches in width around ellipsoids some of which are 6 feet across. Here the spots are a centimetre or less in diameter, and can be seen to be not phenocrysts but circular spots of lava several shades lighter than the main body. They are confined to the outer parts of the ellipsoids, becoming few and diminishing in size a few inches from the edge. Ellipsoidal masses outlined by these peculiarly mottled zones are particularly well shown on the north boundary of mining claim H.R. 374. Between H.R. 374 and Pear lake they give place to the porphyritic type described above. At the south end of the lake is a coarse volcanic breccia consisting of angular fragments of this rock that have been flattened somewhat so as to resemble squeezed conglomerate pebbles. The porphyritic variety occurs at various other points west and southwest of Mosher lake, and is continuously exposed around the east side of Porphyry lake, near Hare lake, and again on Breese lake. In the latter place, however, it has been altered to a light grey schist that strikes in a direction 20° W. of N. The fine-grained ellipsoidal phase has been found on the shores of Lloyd lake in Raymond township, as well as in Tyrrell, apparently covering a considerable area.

Thin sections of the dense material that forms the ellipsoids consist almost entirely of radiating bundles of slender feldspar microlites about one-third of a millimetre long that represent an imperfect spherulitic development. The microlites are clear and unstriated. A pale green glass, partly crystallized, and about equal in area to the microlites, fills the interspaces among them. A few large rectangular sections of feldspar phenocrysts almost a milli-

metre in length are scattered here and there through this groundmass, but the feldspar is too much decomposed to be identified.

A section of the mottled rock that fills the spaces between the ellipsoids presents the same appearance. The spots differ from the rest of the section in no wise except that they appear dusty and less transparent. There is possibly a greater tendency on the part of the microlites to develop feathery skeletal forms, and the large rectangular feldspar phenocrysts appear to be somewhat more abundant within the spots than in the surrounding material. These often protrude marginally as if the spots had suffered partial resorption by the enclosing rock substance, and their groundmass had been attacked more easily than its enclosed phenocrysts. Needle-shaped microlites protrude in similar fashion. The resultant spiny surface of the spots is so delicate a structure that it could only have been developed in place either by crystallization or resorption. The protruding parts of the phenocrysts have lost the perfectly sharp crystal outlines they possessed within the spots, apparently owing to corrosion. Hence it seems likely that the spots represent bits of the lava which, after solidification, were corroded to their present forms by another still liquid portion.

The freshest procurable specimens of the porphyritic variety consist of abundant phenocrysts of feldspar and hornblende, rarely also of quartz, held in a fine mosaic of feldspar, quartz, and chlorite. Most of the feldspar phenocrysts are twinned and behave optically like oligoclase-albite. They decompose to an aggregate consisting mostly of fine scales of colourless mica. Orthoclase appears to be uncommon. Quartz is represented rarely by large imperfect crystals. Common hornblende forms stout prisms smaller than the plagioclase crystals and not quite so numerous. It alters to chlorite and epidote, the latter decomposition product being surprisingly abundant. The groundmass appears as a fine mosaic of the same materials, feldspar predominating.

There is a remarkably close resemblance between this porphyrite and a similarly porphyritic marginal phase of the hornblende granodiorite area, mapped as Laurentian, which lies less than 2 miles to the north, in Knight township. Thin sections of the two are scarcely distinguishable. It is not improbable that a detailed geological examination of this locality might show the porphyrite to be an extrusive phase of the granodiorite. In close proximity to this granodiorite mass—on the islands in Pigeon lake and on the shore

just north of them there is also a fine-grained, weathered porphyritic rock which, near its contact with an old diabase, contains small angular fragments resembling the latter. Whether any connexion exists between the porphyry and the one described above is uncertain.

Burrows[1] found an ash-grey felsite schist near Leroy lake, in the township of Haultain, and a more extensive body of massive porphyry a mile southwest of Everett lake.

Granite Porphyry.—At the south end of Beaverhouse lake, in the township of Knight, the ordinary chloritic schists are cut by a broad dyke of light grey porphyritic granite. It is massive and highly feldspathic, dull white phenocrysts of feldspar being distinguishable from a well crystallized groundmass of the same colour. Dark minerals are virtually absent. A smaller dyke of this kind occurs about half way along the west shore of the lake, but in this case the rock has been sheared to a feldspathic schist. Another of the same kind, so deformed as to appear as a light coloured schistose band in the chloritic schists of the vicinity, was observed a half mile farther north. Bands of this kind a few feet in width occur also at the east end of Foot lake, and elsewhere. Probably all of them were originally dykes.

On the north boundary of Nicol, 8 chains west of the fifth mile post, dark Keewatin schists are cut by an acid rock which has not been seen elsewhere in the district. The mass is dyke-like in form, 120 feet wide, and extends north and south of the township line for at least 500 feet. It is light grey and quite fine-grained near the edges, but for the greater part is given a conspicuous porphyritic texture by closely crowded, thick-tabular crystals of plagioclase up to an inch in length. The groundmass is of medium coarseness and contains visible grains of hornblende. In thin sections the contrast between the large feldspar crystals and the matrix is decided. The former show fine twinning lamellæ whose extinction angles indicate them to be albite. The holocrystalline groundmass consists of smaller plagioclase laths, stout prisms of brown hornblende and a little quartz which fills the angular interstices between the crystals of the other constituents. There are also a few accessory grains of titanite and black iron ore, small rods of apatite, and much secondary epidote. The mineral composition is like that of a granodiorite.

Harzburgite.—Small patches of a basic olivine-rich rock were

[1]A. G. Burrows, Annual Rept. Bureau of Mines (Ontario), 1909, pt. II.

found in Tyrrell and Van Hise townships. The solitary area in Tyrrell is about 500 feet wide, and was traced west from P[illegible]r lake for three-eighths of a mile, after which it was found to be hidden by glacial drift. At its eastern extremity it cuts through the hornblende porphyrite described earlier. In Van Hise this rock is exposed half way down the east shore of Firth lake, also on Serpentine lake, though the swampy ground intervening prevents any possible continuity between these points being determined. Another equally small exposure was found between Foot and Obushkong lakes. At all these points its massive appearance contrasts decidedly with the adjacent chloritic schists, and suggests it to have been intruded subsequently to their foliation.

It is a massive, quite coarse-grained rock, dark green or nearly black in colour, though freshly broken specimens take a bronzy lustre from the cleavage surfaces of its constituent mineral grains. Its recognition is also simplified by the dull green, amorphous looking serpentine which accompanies it, and by a network of asbestos seams traversing it. At the surface these seams are dull white in colour but bright green and glistening when newly broken.

Although considerably decomposed, the outlines of the original mineral grains are well preserved and the original composition can be determined without difficulty. Rhombic pyroxene, hornblende, and olivine are the principal constituents. Large irregular grains of pyroxene and smaller, less abundant ones of hornblende, often mutually intergrown, form a basis in which are embedded numerous rounded or idiomorphic crystals of olivine. A very small amount of plagioclase, some grains of iron ore, and small rods of apatite are the only other primary minerals present. The pyroxene, which forms over one-third of the rock, is non-pleochroic and either enstatite or of a variety of bronzite poor in iron. It is much fractured and decomposes to fibres of serpentine that grow parallel to its vertical axis. Small quantities of brightly polarizing matter, probably talc, were observed along some of the fracture planes. The hornblende is probably rich in magnesia, as it also changes to serpentine, though less readily than the pyroxene. It is optically negative with an extinction angle of at least 15 degrees. The pleochroic tints are: $\mathfrak{c}$ = light sienna brown, $\mathfrak{b}$ = much paler, $\mathfrak{a}$ = colourless. Traces of colourless olivine remain in some places, but most of the crystals of that mineral are replaced by a felty mass of serpentine; the original cracks in it are filled with black iron ore. The few

small and irregular pieces of plagioclase have been changed to kaolin and cannot be further identified. The primary iron ore is also altered to leucoxene. From its mineral composition, this rock seems most closely comparable to the enstatite-bearing basic type, harzburgite. The ultimate product of decomposition is a dull green rock composed solely of serpentine, even the secondary iron ore being absent or locally segregated.

It seems probable that basic rocks of this sort are not confined to the few localities already described. Asbestos has been found near Mount Sinclair, a few miles north of Raymond township, in association with a black massive rock. On some of the islands near the middle of Pigeon lake there is also a badly decomposed rock of similar nature. This was first described by Dr. Bell and shown, by a chemical analysis made by Mr. B. J. Harrington,[1] to be a peridotite. A mile south of these islands on the east shore, and also on the 63 chain portage to Breese lake, Tyrrell township, there are small patches of a tough green rock, composed largely of a felty mass of actinolite needles, but which, under the microscope, show also a large quantity of serpentine.

Diabase.—Under this name are grouped rocks which were regarded as diabase in the field, and have been given no subsequent microscopic examination. Rarely they are fresh enough for the laths of feldspar to be seen in hand specimens, but more commonly they are chloritized to a uniform dull green colour and may also be somewhat schistose. Rocks of this kind underlie most of the country between Pigeon lake and the Algoma boundary. Massive dark green diabase occurs on both sides of Pigeon lake at its central islanded part, and extends from there up the lake and the river above to Arthur lake. Apparently it is the oldest rock in that vicinity, for it is underlain on the east shore of Pigeon lake by a dull grey porphyrite and intruded by the neighbouring large bodies of hornblende granodiorite. It is badly decomposed and fractured. Around the little bay in Pigeon lake, just north of Brush lake, it forms a low wall the face of which is traversed by a close network of calcite-filled cracks. On the east shore just opposite, it has been sheared locally so as to leave well rounded lumps of the more resistant parts embedded in a fine chloritic schist, producing thereby a pseudo-conglomeratic appearance.

[1]B. J. Harrington, Ann. Rept., G. S. C. 1876–77, p. 483.

A black diabasic rock containing numerous small crystals of pyrite outcrops repeatedly in the Keewatin area east of Duncan lake. Although the adjoining rocks are schistose, it is massive and rather fresh looking. Diabase also occurs between Firth and Obushkong lakes, though nearly always foliated and grading into chloritic schists.

Diabase occurs on both sides of Shiningtree lake. It is locally ellipsoidal. On the south line of McMurchy township, a mile west of this lake, what is apparently the same rock contains numerous vesicular cavities, so it is evidently extrusive.

Diopside-bearing Diabase.—A fine-grained rock of dioritic appearance was found a few chains west of Pear lake, where it occupies undetermined but certainly very small areas, probably representing dykes. Its general colour is dull greenish grey, but on closer inspection it appears finely speckled, grains of a grey green ferro-magnesian mineral one millimetre in diameter being distributed through the main feldspathic body of the rock. It has suffered no perceptible deformation. In the neighbourhood of Lloyd lake, where it is more common, this rock seems to pass gradually into a glassy, volcanic type exhibiting flow structures and vesicular cavities. There are, however, in the same locality, volcanic phases of the hornblende porphyrite described earlier, and the resemblance of the two is so great that they cannot be distinguished with certainty in the field.

The more coarsely crystalline specimens consist wholly of a monoclinic pyroxene and feldspar in nearly equal amounts. An ophitic texture can be recognized, though the pyroxene is often in perfect crystals. This constituent is colourless in thin slices and agrees in its other optical properties with magnesia-rich diopside. The feldspars cannot now be identified, being replaced by an aggregate of secondary minerals in which epidote, calcite, and secondary quartz are most common. A few crystals of primary magnetite and irregular grains of pyrite are also present.

Augite Basalt and Hornblende Andesite.—These rocks are most abundant in the townships of Tyrrell and Knight, west of the West branch. They have been traced along the boundary between these townships from the western edge of the Huronian slate to a point about midway between the fourth and fifth mile posts. For over a

mile north of this line they occur around the edge of the granite mass mapped as Laurentian, small fragments being often included within the latter. They do not extend continuously far southward, though small patches and outcrops recur frequently as far as Mosher lake. In Tyrrell township they are confined within an area of 8 square miles. On the west side of the West branch, half way between Arthur and Pigeon lakes, hornblende andesite overlies an old decomposed diabase. A low wall of the same rock was met a few hundred feet east of mile post 67 on the Algoma boundary line.

Although both augite-bearing and hornblende-bearing types occur, they cannot be distinguished without the aid of a microscope Both are massive, dark green rocks which on close inspection can be seen to be porphyritic, stout black or very dark green prisms of hornblende or pyroxene being abundantly scattered through a fine groundmass a few shades lighter in colour. In places they become coarser grained and dioritic in appearance, but the glistening cleavage faces of the hornblende and pyroxene serve to distinguish them from other associated Keewatin rocks.

The augite-bearing species varies from basaltic to diabasic in texture, with increasing coarseness. In thin sections of the former sharply idiomorphic crystals of colourless augite and biotite are distributed through an extremely fine-grained though holocrystalline groundmass. The augite is perfectly fresh, but the biotite has been largely replaced by chlorite within which lie lenses of secondary quartz. In the coarser variety the groundmass is more coarsely crystallized, and an intermediate plagioclase appears in considerable abundance; also accessory magnetite.

Sections of the hornblendic type are composed essentially of common green hornblende and andesine, the latter being more abundant. Orthoclase is subordinate, quartz likewise. Magnetite and long rods of apatite are accessories. The relations of hornblende and plagioclase vary considerably. In fine-grained types the former occurs as well formed, elongated prisms, being, together with apatite, the only idiomorphic constituent; but where the crystallization of the rock reaches its greatest observed coarseness—about that of a medium grained granite—the plagioclase assumes the shape of rude laths which penetrate ophitically irregular grains of hornblende.

Iron Formation.—On the east side of Fournier lake, near the centre of Leonard township, a ridge of iron formation can be traced north and south for 1½ miles. The average width is 350 feet. At the south it dies out in a swamp; northward the country is sandy, and Huronian formation overlies the Keewatin. The ridge is composed of succession of elongated patches of iron formation mingled with green schists which have resisted erosion somewhat better than the greenstones and green schists on either side of it. Both schist and iron formation dip 85° west, the strike coinciding with the axis of the ridge. A little iron formation occurs also on the west side of Fournier lake, and at a few other points short distances away from the main ridge.

The patches of iron formation are not sharply defined from the enclosing schists, and usually contain much interbanded chloritic and rusty or cream coloured sericitic schists. The iron formation is cherty looking, indistinctly banded and dull grey of different shades. Across the strike grey bands alternate with a number of darker ones from 1 to 5 feet wide, which contain enough magnetite and hematite to form a lean iron ore. The dark bands taper and disappear along the strike, and are usually weathered and encrusted with limonite at the surface.

A small band of brilliantly coloured banded iron formation or jaspilite crosses the northeastern corner of mining location H.S. 750, in the southwest corner of Tyrrell township. It is not over 50 feet wide and was traced for a distance of only 200 feet, being elsewhere concealed by swamp. However, as it produced a local magnetic variation of 10°, its course beneath the swamp might be determined without much difficulty. Unlike the poorly banded grey formation seen at Fournier lake, this consists of regular alternating bands of brilliant red and black from one-fourth to one-half an inch wide, but they are tilted in the same steep manner—80° E.—and strike north 10° W.

A third strip of iron formation occurs farther northwest and in the line of strike of the two areas just mentioned. It lies a few chains west of the Algoma boundary line at 53 chains north of mile post 61, and, therefore, does not appear on the accompanying map. According to Burwash, who first described it, this body is 100 yards wide and traceable in a northwesterly direction for half a mile.

A small patch of iron formation also occurs about half a mile northeast of Gowganda village, in association with Keewatin green

schists and dykes of quartz diabase which intersect it. It possesses the usual regular alternation of siliceous and magnetite bearing laminæ, the former being light grey in colour, the latter bluish black and glossy, and the general colouring consequently dull. The bands are much crumpled, but the general strike of the formation seems to be about east-west.

A peculiar metamorphic type of iron formation may be seen on the Haultain-Nicol boundary, a few chains east of the second mile post, just where the Keewatin emerges from beneath Huronian beds. For a width of a few feet at this point there is a green, faintly mottled rock which affects the compass needle to about the same degree as ordinary iron formation. Under the microscope, it consists of the usual fine mosaic of quartz grains, but the parallel arrangement of siliceous and magnetite bearing bands is absent. Instead, shreds of chlorite and magnetite crystals are aggregated into oval spots of about 3 millimetres diameter, so as to produce a conspicuous mottling observable even in hand specimens. Chlorite is also disseminated in lesser amounts through the quartz mosaic. In another specimen small sheaf-like aggregations of a secondary amphibole take the place of chlorite.

Graphitic Slate.—A black, slaty rock containing enough powdery graphitic material on its cleavage surfaces to soil the fingers was obtained at the contact between Keewatin hornblende andesite and a dyke of porphyritic hornblende syenite on Brush lake, Knight township. It is the only carbon-bearing rock observed in the Keewatin, or indeed in any of the formations in the district. It was observed only within a few feet of the intrusive dyke.

SCHISTOSE METAMORPHIC TYPES

Distribution.—A marginal arrangement of schistose rocks around the less disturbed ones in Tyrrell, Knight, and Raymond townships, is expressed not only by the actual distribution of the former so far as can be seen, but also by their foliation. The dip of these schists is always very steep, but the direction of strike curves about so as to be parallel to the Keewatin-Laurentian contact wherever the latter can be seen. Its course across the district can be traced with little difficulty. Beginning at the north side of Rankin township, there is a small area of well foliated Keewatin, composed mostly of chlorite schists, though on the east side this

grades into hornblende schist. The average strike is south 60° west. The southerly extent of these rocks is concealed by overlying Huronian formation, but, 3 miles away in about the direction of strike they reappear, forming a larger area between Duncan lake and the West branch. Here again chlorite schists merge toward the east into a crystalline hornblendic variety. There are also occasional residual patches of massive rock in the schists that appear to have resisted deformation better than the surrounding foliated materials from which they are not distinctly separable. In the northern part of this area the foliation is nearly north-south, but toward the south swings to south 25° east.

The Huronian again intervenes, but 3 miles farther, in the direction of curving strike, the schists are once more exposed in Van Hise township. Residual, massive cores are to be found about Serpentine lake, but a schistose structure prevails elsewhere. Near Firth lake the strike varies from east to east 30° south. Approaching Obushkong lake it trends northeasterly in the northern part, and southeasterly in the southern as if preparing to spread around the circular Laurentian body in Haultain township just to the east. The southeasterly foliation is probably continuous into the township of Nicol, where the Keewatin is again exposed, and, according to Mr. Burrows, who examined this part of the district in 1908, consists of chloritic, felsitic, and hornblende schists, with some more massive material. The strike of these rocks along the north line of Nicol varies from east 20° south to east 50° south. Farther south near LeRoy lake, Burrows found it to be south 65° west. From here southward and westward the crystalline basement is seen only rarely through holes in the Huronian mantle, but at such points it is Keewatin. Mr. Burrows' description of the small area west of Elkhorn lake has not yet been published, but the other patch on the west side of Milner township is known to be imperfectly schistose. Finally, the Keewatin in Leonard township is well foliated in a north and south direction, the schists in the southern part of that township being especially fissile.

Chloritic Schist.—By far the greater part of the schistose zone consists of chloritic schists. In its most highly developed form this is a slaty, dull green rock, readily cleavable into plates that present a glossy, micaceous surface. But commonly, the cleavage is less perfect, and there persist some characteristics of the original materials from which the schist has been derived. The chlorite

schist west of Firth lake grades in places into massive diabasic rock. Just east of Foot lake, and again in the extreme southeastern corner of Knight township, a fissile chloritic schist was found to carry oval grey spots flattened in the plane of schistosity which represent the crushed feldspar phenocrysts of some porphyritic rock. Besides being traceable back to original massive types, the chlorite schists can be observed to pass by more extreme metamorphism into a hornblende schist, consequently it exhibits only an approximate constancy in lithological character.

Felsitic and Sericitic Schists.—In the neighbourhood of Beaverhouse lake, Knight township, the prevalently dark coloured schists are traversed by occasional light grey bands a few feet in width. These in some cases are highly schistose, but in others can still be recognized as granite porphyry dykes. Similarly, on Breese lake there is an ash coloured felsitic schist striking north 20° west and dipping vertically, which has been produced by local shearing of the porphyritic rock which underlies that part of Tyrrell township.

CONTACT METAMORPHIC TYPES.

Between the fissile schists just described and the Laurentian lies a narrow band of highly crystalline contact metamorphic products that, in Gowganda district, consists almost altogether of hornblende schist. Toward the Laurentian it presents a ragged surface from which fragments have been separated partly or altogether and enclosed within the gneiss; in the opposite direction it merges by degrees into chloritic schists. The limits of this contact aureole are, therefore, not very definite. However, the average width is not far from a half mile.

As the hornblende schist is restricted to the immediate neighbourhood of the Laurentian and strikes parallel to the contact, it furnishes a criterion for determining the position of this contact and the shape of the main Keewatin area to which all the smaller visible areas belong. It is confined to a single band that can be traced across Gowganda district. This band appears first in the eastern side of the Keewatin that lies just north of Rankin township. As it contains occasional ribbons of gneiss it is probable that the Laurentian underlies the Huronian only a short distance to the east. Hornblende schist recurs along the east side of the next

Keewatin area to the south. Near L'Africain lake its relations to the Laurentian are unusually well shown. The west side of the lake consists wholly of hornblende schist which, farther west, graduates into green chloritic schists. On the east shore the hornblende schist is traversed parallel to the strike and at considerable intervals by ribbons of hornblende granite a few feet or inches in width. Farther east these intrusive ribbons grow broader, until at a distance of half a mile from the lake the quantitative relations are reversed and ribbons of hornblende schist occur at intervals in Laurentian hornblende granite. These at a still greater distance dwindle in importance to scattered intrusions. Hornblende schist extends around the north and east sides of the Keewatin area in Van Hise, thence east toward Everett lake. A strip of it also reaches across the middle of Haultain township, thus marking off from the main Laurentian area a circular patch 2 square miles in extent. Imperfectly developed hornblende-chlorite schist occurs in the Miller Lake area, but from there southward it is not again exposed within the confines of the area under consideration. It does occur, however, a few miles farther south. Except as inclusions in the Laurentian, hornblende schist has not been found anywhere outside the sinuous band just traced.

Though specimens of this rock taken at different distances away from the Laurentian vary considerably, they are all distinguished by an abundance of jet black glistening hornblende. At the contact it is a coarse amphibolite schist or gneiss, according to the lack or abundance of light coloured minerals. The foliation is more pronounced than in an ordinary gneiss. Farther back from the contact it grows finer, pure glistering black in colour, and more schistose, splitting like wood in one direction into flat plates and splinters. Still farther from Laurentian influence it grows chloritic, less strikingly crystalline, and finally indistinguishable from chlorite schists.

This transition from chlorite schist to amphibolite is readily traceable with the aid of the microscope. Hornblende first appears in a confused aggregation of secondary minerals that constitute a chlorite schist, in the form of slender needles so oriented as to lie in the plane of schistosity. In a more advanced stage, hornblende entirely replaces chlorite, and the cloudy mixture of other secondary minerals gives place to a very fine mosaic of quartz, feldspar, and epidote or zoisite, with smaller amounts of magnetite, titanite, pyrite, etc. The hornblende grains are arranged with their long

axes in the same direction, so as to produce a decided schistosity. More extreme metamorphism gradually eliminates epidote and zoisite, enlarges the grains of the remaining minerals, and reduces the degree of schistosity. Hence the final product, found in the immediate vicinity of the Laurentian contact, is a comparatively coarse gneiss composed of anhedral grains of notably uniform size.

The freshness of all the constituents is not less noteworthy. Hornblende, feldspar, and quartz make up most of the rock. Irregular, often large grains of titanite, magnetite, pyrite, and small sharply hexagonal rods of apatite are accessory. Rarely there are also a few crystals or grains of colourless garnet. Deterioration of the schistosity appears to result from the changing habit of the hornblende; as individuals of this mineral grow larger they gradually change from an acicular to a stout granular form. The pleochroism of the hornblende is characteristic: $\mathfrak{a}$ = yellowish-green, $\mathfrak{b}$ = deep brownish-green, $\mathfrak{c}$ = blue-green. Inclusions of apatite crystals are often surrounded by dark pleochroic halos. The feldspars are glassy clear. Acid plagioclase is most abundant, but microcline and orthoclase are also present.

Biotite may also be present, sometimes displacing hornblende to such an extent that the rock becomes a biotite schist. However, this biotite schist is seldom found in the Gowganda area, where the original Keewatin rocks are predominantly basic and give rise to chlorite schists, and these in their turn to hornblende schists.

Conditions During Keewatin Time.—The Keewatin complex is predominantly igneous. With the exception of an inconsiderable amount of graphitic slate, iron formation is the only sediment, and even this is not abundant. Igneous rocks, on the contrary, are in great variety, ranging from acid to basic types. Volcanic breccia, amygdaloidal and ellipsoidal structures found in the hornblende porphyrite and diabase indicate that these rocks at least are extrusive. Most of the other varieties are fine-grained, but whether intrusive or extrusive cannot be proven conclusively, though the occurrence of tufaceous rocks at several points in the district implies some further extrusive action. The harzburgite masses are probably intrusive. Briefly, vulcanism of complex character is responsible for nearly all of the Keewatin group.

Though the complexity of vulcanism is suggestive of protracted duration, no positive inferences can be safely made upon this point. Almost as little evidence appears to exist regarding surface condi-

tions, but there are two features which imply submergence. The investigations of VanHise, Leith, and others in the Lake Superior region have developed a convincing mass of evidence showing that iron formation represents an original aqueous chemical precipitate of iron carbonate and silicate. It is found lying directly upon uneroded surfaces of volcanic flows that are characterized by ellipsoidal structures. Iron formation of Huronian age is conformably associated with ordinary subaqueous sediment. And further, the original iron carbonate and silicate were ferrous compounds, and the latter has been artificially produced by precipitation from aqueous solution. The existence of Keewatin iron formation in Gowganda district would, therefore, indicate it to have been under water for at least a part of Keewatin time. Observations, including those of Sir Archibald Geikie in Great Britain, Dr. T. Anderson in Iceland, and others, are accumulating to show that ellipsoidal structure in volcanic rocks is peculiar to subaqueous extrusions. In this light the pronounced ellipsoidal development in the porphyritic rocks of Tyrrell and Leonard townships offers further evidence of submergence.

Laurentian.

DISTRIBUTION.

The visible portion of the Laurentian is confined largely to the north side of the map-sheet, extending from Smyth township as far west as Knight. Southward it passes under the Huronian sedimentary mantle. How far it continues beneath the Huronian in that direction cannot be definitely ascertained, but in Shillington, Willet, Lawson, and even as far south as Corkill township, erosion has worn holes in the sedimentary cover and in every case laid bare a floor of Laurentian gneiss. Hence it is not unlikely that much or all of the crystalline basement in the eastern half of the area mapped is Laurentian. There is also a small isolated body of hornblende syenite southwest of Pigeon lake.

LITHOLOGICAL CHARACTER.

Uniformly coarse granitic texture and grey or reddish colours easily distinguish the Laurentian from any of the other Pre-Cambrian rocks. They are much less perfectly foliated than the

Keewatin schists, ranging from well defined gneisses to perfectly massive granite. The gneissic varieties show little constancy in dip or strike. Two principal species are distinguishable: biotite granite and a hornblende granite with local syenitic phases.

The hornblende granite is a medium grained, fresh looking rock, given a speckled appearance by the black hornblende crystals that lie scattered through the main body of grey feldspar and quartz. It is never very rich in quartz, which often diminishes to accessory proportions or disappears entirely. Thin sections are composed of oligoclase, hornblende, orthoclase, and quartz; crystals of apatite, zircon, and magnetite are accessory. The hornblende is the common green variety, and quite fresh, hence a few flakes of chlorite in the section were taken to represent an original small content of biotite. Finely striated oligoclase is much the most abundant constituent, and greatly in excess of orthoclase.

The biotite granite is of much the same texture as the hornblende-bearing type, except that it is usually more pronouncedly gneissoid. Biotite, more or less altered to chlorite, is a fairly abundant constituent; sometimes scales of it enclose large feldspar grains so as to produce a slight augen structure. Coarse phases and pegmatite are not uncommon, as are also stockwork-like masses of quartz, of which at least the former represent acid variations of the original material. Vaguely defined schlieren, richer in biotite and consequently darker coloured than the surrounding gneiss, are believed to be basic segregations.

The true Laurentian gneisses frequently contain ribbons or lenses of glistening black hornblende schists, identical with the hornblende schist found about the edge of the Keewatin areas. Field relations indicate pretty clearly that such bodies are really inclusions of Keewatin that have been recrystallized and drawn out to their present shapes by Laurentian movements. They are especially common near Keewatin contacts, into which they are often directly traceable, but are by no means restricted to such places, for at the south end of Mistinikon lake and other points equally remote from a Keewatin area, the Laurentian is crowded with them. The narrow band of Keewatin that extends from the north end of Everett lake to Obushkong lake is really Laurentian densely crowded with inclusions of Keewatin hornblende schist.

LOCAL DESCRIPTION.

Biotite granite or gneiss is the prevalent Laurentian rock. Hornblende granite or gneiss is exposed at intervals along Montreal river from Indian chute up to the Fort. It is again present over a rather large area on either side of Sedge lake. As contacts or passage from one variety to the other have never been observed, their relations to each other are unknown.

The small area near Pigeon lake differs in some respects from the typical Laurentian formation. It has exercised very little metamorphic effect upon the adjacent Keewatin rocks, and the aureole of hornblende schist present at other Keewatin-Laurentian contacts is not found. On the contrary, Keewatin specimens taken at the line of contact retain perfectly their original characters. And the intrusive syenite has been chilled by contact with the older Keewatin, with the result that it is porphyritic and much finer grained around the edge than within the mass. The average rock type is a massive, medium grained syenite, much like the hornblende granite found elsewhere. The marginal porphyritic phase, however, shows square white crystals of feldspar embedded in a fine bluish-grey groundmass. In mineral composition it also resembles the hornblende granite. Oligoclase forms a large part of its mass, while orthoclase is quite subordinate. A few small grains of quartz are usually present. Common hornblende is the only ferromagnesian mineral. In the porphyritic phase large crystals of oligoclase and smaller thick prisms of hornblende lie in a holocrystalline matrix composed of all the constituents of the rock. It has already been suggested that this syenitic mass may be directly related to the extrusive hornblende porphyrite found in the adjacent Keewatin.

Huronian.

The lower and upper series into which the Huronian sedimentary mantle of Timiskaming region is divisible were first recognized by Miller in Cobalt district and given the respective names, Cobalt series and Lorrain series. As the two series have been traced almost continuously from Cobalt to Gowganda, and their relations and lithological nature are everywhere alike, it is practically certain that the succession at Gowganda is comparable with that at Cobalt. Hence the names supplied by Miller are employed again in the

PLATE II.

Obuskong lake, looking northward. Photo by C. J. Wallis.

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following description, Cobalt series referring to a lower series of conglomerate greywacke and slate principally, and Lorrain series to an immediately overlying one of quartzitic composition.

A line drawn diagonally across the accompanying map between James and Leith townships separates the two series fairly completely. Nearly all the Cobalt series lies northwest, and most of the Lorrain series southeast of it.

COBALT SERIES.

In nearly all places where the bottom of the Cobalt series has been seen its lowermost member is a conglomerate. On the west side of Mosher lake greywacke rests directly against the Keewatin, but as the greywacke often contains sparsely distributed pebbles, even this may be no exception. Above the basal conglomerate, however, the order of succession is not constant. Where the conglomerate possesses a sandy cement it passes upward into grit or impure quartzite; if the cement is of greywacke or slate the overlying formation is also greywacke or slate. These two materials are often mutually interbedded, and in their lowermost parts they alternate with small cross-bedded lenses of conglomerate. They also pass upward, just as they do downward, into a conglomerate physically identical with the basal one. Successions of this kind are repeated in the faces of the cliffs climbed going from Duncan lake across to the West branch.

The upper portion of the series has been eroded, and consequently its original thickness is unknown. In its present condition observed sections vary, from nil up to 500 feet. It seems probable that a thickness of 1,000 feet is seldom reached.

Lithological Character.

Rhyolite.—The Cobalt series is entirely sedimentary; but in the northern part of the township of Leonard it is closely associated with a sheet of rhyolite accompanied by tufaceous deposits of the same material. The flow occupies the interval between Black and Spider lakes, extending thence into the southern part of Tyrrell township. Its thickness, though not determined, does not appear to be great. It is surrounded on all sides by coarse volcanic breccia, which in its turn merges into the basal conglomerate or becomes

imperfectly assorted and interbedded with slate. Extrusion of the lava took place somewhat earlier than the deposition of the sedimentary series. Fragmental matter was first ejected, forming a lower breccia. This was succeeded by a flow of lava and another shower of debris. In some places the breccia lies directly upon Keewatin greenstone. East of Black lake it grades into conglomerate, and on the shore of Black lake itself there has been an assortment of the finer fragments into a sort of arkose which is interbedded with slate. The slate in this vicinity is inclined 70° west, though on Spider lake it is horizontal.

The lower part of the flow, exposed along the west side of Black lake, consists of a pale grey rock, quite massive and without amygdaloidal or flow structures. Minute, glassy phenocrysts of quartz and somewhat larger white ones of feldspar are scattered sparingly through a light grey groundmass. The crystalline texture becomes more distinct a little farther west, but before reaching Spider lake it is again fine and accompanied by amygdules. The latter are half an inch or less in diameter, globular in form and filled with calcite, except at the surface where they are empty. It is perhaps noteworthy that this superficial leached zone is less than an inch thick. The associated breccia is of variable coarseness. That seen on Spider and Black lakes consists of angular vesicular fragments up to a foot in length. The interstitial matter is for the greater part also fragmental, though in some places it is a dark grey ropy lava. Pyrite, either in small nests or as scattered crystals, is abundant. A mile north of Black lake in Tyrrell township there is also a much finer brownish ash rock that has been fairly well stratified. In the same vicinity the tuff has been partly assorted and, farther north and west, grades into a white arkose-like rock which is in places interbedded with slate.

Thin sections of the rhyolite exhibit a strongly porphyritic texture. The groundmass, even in the most coarsely crystallized specimens, is very fine-grained and contains perfectly outlined phenocrysts of feldspar, quartz, a decomposed ferromagnesian mineral and pyrite. Both orthoclase and plagioclase—oligoclase-albite—are present, the latter forming much larger crystals than any other constituent. Quartz individuals are small but very numerous, and possess a crystal habit frequently seen in the quartz of acid volcanic rocks. Most of them yield square or rhomboid sections that extinguish diagonally. When cut normal to the

vertical axis the outlines are triangular, sometimes with bevelled angles. A rhombohedron approximating in form to a cube appears to be the dominant crystal form. The ferro-magnesian mineral has been so completely changed to chlorite and epidote that it cannot be identified. It is much less abundant than either quartz or feldspar. Pyrite occurs in small crystals. Vesicles when present are filled with calcite or calcite and quartz; the calcite is frequently in two individuals, one encrusting the cavity walls, the other filling the remaining central space. Quartz may form a layer between the two calcite individuals.

Conglomerate. At one point on the east side of Lake Timiskaming, Barlow[1] accords to the conglomerate a depth of 600 feet. Throughout Gowganda Mining Division it also forms an important part of the series, though the incomplete sections observed do not often exceed 75 feet. In one of the hills west of Duncan lake a thickness of 200 feet is visible, though neither top nor bottom can be seen. But just above Nest lake, on the East branch, it is not over 25 feet thick and rarely it is apparently lacking. Hence its thickness is evidently inconstant.

Its pebbles and boulders have been derived largely or entirely from the old crystalline floor. Both the hornblende and biotite granites of the Laurentian and their gneissic phases are abundantly represented. Pegmatite pebbles are sometimes found, but that rock is more frequently represented by large fragments of quartz and of feldspar. Pieces of glistening black hornblende gneiss and similarly well laminated biotite gneiss have evidently come from the metamorphic aureole that surrounds Keewatin areas, while the Keewatin proper is represented by altered diabase, porphyroids, etc. Iron formation pebbles are common in the northern part of Leonard township. Vein quartz, sometimes mineralized, is also present, and once a well preserved quartz crystal over an inch long was found. A solitary smoothly rounded pebble of pyrite has been laid bare by some prospector's hammer just where the Algoma boundary meets the southwest shore of Shiningtree lake. The pyrite is perfectly fresh. In addition to these some pebbles resembling slates were noticed, also one which is itself apparently conglomerate. A thin section of this pebble exhibits well defined clastic structure. The fragments assembled in it are rounded, and include such unlike

[1] A. E. Barlow, Ann. Rept. G. S. C., 1897.

materials as quartz, [illegible] what is found in the Keewatin near P[illegible] [illegible]d another siliceous one of micro-crystalline habit. The original cement is changed largely to chlorite in which, however, small angular grains of quartz can be seen.

The conglomerate pebbles are as variable in form and size as in lithological composition. Normally they are well rounded and are assorted as in an ordinary beach deposit; at other times they are angular or subangular. Angular and rounded ones may occur in company. In size they range from sand grains up to 6 inches in diameter, occasionally a foot and rarely 2 or 3 feet. A granite [illegible] 5 feet long was observed in the conglomerate that forms an island in Duncan lake 2½ miles from the outlet. All the fragments accompanying it were very much smaller. At the Blackburn mine, near Miller lake, there is a giant variety of conglomerate crowded with boulders, many of which are 2 feet in diameter.

At the point last mentioned the boulders are packed closely together, with just enough coarse cement to bind them. In other cases the pebbles are scattered to a remarkable degree; for example, the greywacke seen along the West branch below the Notch has granite pebbles distributed through it at intervals of yards from one another. Ordinarily, however, the proportion of cementing to cemented material is more nearly equal. This proportion is in some way related to the kind of cement. Where the pebbles are abundant and well assorted it consists of fine gravel or sand and the conglomerate so formed may be quite porous, and is very frequently cross-bedded. When few in number and widely scattered, the pebbles are embedded in greywacke or fine black slate. Conglomerate with slaty cementing matter occurs near the head of Pigeon lake, in Shillington township, and other localities.

Greywacke.—A bedded structure is seldom distinct in the greywacke and frequently not observable at all. Scattered boulders have been found in it near the head of Pigeon lake, and on the West branch, at which point it suggests a consolidated glacial till. Though hard and compact there has been comparatively little cementation; the minute individuals of quartz and feldspar retain their original fragmental shapes. The feldspar is not greatly decomposed. Often it is clear and shows clear cut twinning lamellæ. Imperfect weathering of the original materials is further manifested by an abundance

of ferro-magnesian constituents now entirely altered to chlorite, which makes up about one-fourth of the whole.

Slate.—The slate, or siliceous shale as it may also be appropriately termed, is a delicately stratified rock made up of fine layers ordinarily about one-tenth of an inch thick. Of a uniform dark grey colour when examined at arm's length, a closer inspection reveals thin alternating bands of dark grey and dull red. This banding is much more conspicuous upon exposed surfaces where the bands have weathered unequally and bleached to more contrastful dark and pale grey shades. The rock cleaves readily parallel to the banding into thick plates. The nature of the banding is shown very distinctly under the microscope (fig. 1, Plate III). From the illustration it may be seen that each lamina is composed of fragmentary material, like very fine sand at the bottom and growing progressively finer toward the top. The banded appearance of the slate is due not to differences in the successive laminæ, but t is variation within each of them. The lower coarse-grained port each is reddish coloured when freshly exposed and weathers to a whitish ridge, while the upper fine-grained portion is dark grey and weathers into a groove. The whole structure is comparable to the grain of wood. For any one locality the laminæ or minute strata are of very uniform thickness. For most of the district they do not exceed an eighth of an inch, but on Spider lake, in Leonard township, they are one-fourth inch thick and distinguishable from a distance. Though in each layer fine and coarse materials are segregated from each other, the latter especially show imperfect assortment. The illustration shows one fragment many times larger than any of its neighbours, a feature which is of repeated occurrence. These exceptionally large pieces range in size from small sand grains up to that of a pea, and in a few instances solitary granite pebbles several inches in diameter have been found. In fact this banded slate not infrequently forms the cementing material of the conglomerate. It is interesting to note that many of the enclosed fragments are quartzite composed of well rounded sand grains thoroughly cemented together.

The slate was deposited under water, and successive laminæ or tiny strata represent a brief recurrent process of sedimentation of uniform character and equal duration; otherwise they would not be so uniformly thin. The rapid change in each from coarse to fine

matter implies a similarly rapid decline in carrying power of the water current. It is difficult, however, to conceive of a current of water capable of carrying the granite boulders found in the slate and not destroying this delicate stratification. More probably the boulders were carried by floating ice and dropped quietly into the mud from which the slate has been derived.

The slate is locally brecciated and reconsolidated under conditions not easy of explanation. Thus on one of the little islands at the foot of Duncan lake where the band of slate, except for being inclined about 20°, shows no sign of severe disturbance, there is one brecciated band a foot wide lying between beds of the same material in which the delicate parallel stratification is perfectly preserved. This layer, which is conformable with the bedding planes of the formation, is composed of angular slate fragments a few inches in diameter that show no disturbance of their fine banding, and have been again consolidated without the aid of other cementing matter. At another place, near the head of Pigeon lake, the brecciated fragments have been bent and pressed together in such a way that neither the outlines of the individual fragments nor their lamination can be clearly defined. The same thing has been noted west of Bloom lake. It would seem to have been produced during the period of deposition, for the absence of shearing in the brecciated layer, its sharp definitions and conformability with the stratification, as well as the repose of both over and underlying beds, can scarcely be accounted for were it due to dislocation in already hardened strata. And yet the fractured material was sufficiently consolidated to break into angular pieces without other deformation.

The slate is sometimes tinged a dull red by an unusually large percentage of iron oxide. A variety of this kind looking somewhat like hematite but in reality a poorly ferruginous slate, occurs in the southwest of Chown township, also on Elkhorn lake. Burrows found 7 per cent of soluble ferric oxide in a sample from the former locality.

Arkose and Quartzite.—At the middle, islanded part of Duncan lake, greywacke gives place upward in gradational manner to an arkose that bears very considerable outward resemblance to granite. However, the quartz grains are visibly rounded. There are also a few conglomerate layers present. The greywacke on the west side of Gowganda lake frequently becomes coarse and feldspathic enough

to be considered as arkose. In the eastern portion of Morel township a feldspathic quartzite carrying well rounded granite pebbles in its lowermost part overlies the Laurentian and is itself overlain by slate.

Relations of the Cobalt Series to the Crystalline Basement.

The Cobalt series lies with pronounced unconformity upon the older crystalline floor. It is horizontal or dips at most 30 degrees, while the older rocks, particularly Keewatin schists, are approximately vertical. Contacts with Laurentian granite are sharp and show no intrusive effects. Pebbles in the basal conglomerate consist almost exclusively of Keewatin and Laurentian materials.

In only three of the twenty-four townships shown upon the accompanying map does the crystalline basement not appear at the surface at one or more points. Even where it is still overlain by Huronian beds the covering does not appear to be of great thickness. Some valleys in Willet township that are 200 feet deep extend completely through the sedimentary series to Laurentian gneiss. Again in Shillington township small patches of Laurentian continue to appear from beneath the Huronian for 2 or 3 miles beyond the main line of contact between these formations, as if the plane of contact shelved southward at a low angle. It seems highly probable, therefore, that the Huronian was deposited upon a surface never far below the present one and of the same peneplanated type. Some pre-Huronian hills can still be seen protruding through the sedimentary blanket. Such is the case near Mosher lake, where Huronian slate, dipping at a small angle, abuts directly against the bases of Keewatin hills 300 feet in height. Slate dipping 15 degrees abuts in the same manner against the side of a knob of hornblende syenite on the east side of Pigeon lake.

The Huronian beds are usually too thick to be conveniently broken away so as to reveal fresh portions of the surface upon which they lie. At one point, however, on Wapus creek, not far from the third mile post of the Milner-Tyrrell boundary, exceptionally favourable circumstances were encountered. There, glaciation has left a few scales of Huronian conglomerate adhering tightly to a knoll of Keewatin. When a little was chiselled off, the original pre-Huronian surface so exposed was found to be even smoother than the adjoining recently glaciated one, for it had not been etched like the latter

by ordinary erosive agencies. Striæ were not detected; the probability of finding them on so small an area as that uncovered—a square foot or more—was but slight. Later, another place was found on the East branch a mile above Nest lake, where, in the side of a low wall, a horizontal contact between Huronian quartzite and Laurentian gneiss was represented by a crevice wide enough to admit the hand. The sharply defined under-surface that could be seen near the outside, and felt a little farther in, was also smooth. At one point on the east shore of Shiningtree lake, Keewatin schists are overlain by thin scales of conglomerate. There, so far as could be observed, the contact was not smooth but harsh and angular, like existing Keewatin surfaces. And Miller[1] describes Keewatin-Huronian contacts near Lake Timiskaming, where a breccia formed in situ rests upon fractured greenstone.

LORRAIN SERIES.

Practically the whole Lorrain series consists of feldspathic quartzite. A breccia or conglomerate may be present at its base, but in a few localities where the bottom has been seen this has a thickness of only a few feet or is quite absent. Streaks of quartzite conglomerate, apparently of small extent, are frequently met higher up in the formation. Only these coarsely clastic rocks occur within the area here dealt with, but immediately to the south the quartzite contains a buff coloured chert and some limestone.

The series is known to have a thickness of 600 feet, and this amount is probably greatly exceeded.

Lithological Character.

Macroscopic Description.—The quartzite is sometimes remarkably pure and marble white, but as a rule contains feldspar, often in sufficient abundance to become an arkose. Correspondingly its colour may be grey, pink, or pale green. Where exposed to the weather the feldspar grains become chalky looking and render the rounded quartz grains unusually conspicuous, but even without this aid the clastic texture is unmistakable. Bedding planes in the arkose or quartzite are not readily seen in low glaciated exposures, owing to the layers being several feet thick; they are plain enough,

[1]W. G. Miller, Ann. Rept. Bureau of Mines (Ontario), 1907, Pt. II.

however, in the sides of hills and cliffs, and it is likely that a bedded arrangement exists throughout the formation. Ripple-marks and cross-bedding are also common. The latter structure is well shown at the north end of the large island in Gowganda lake, but ripple-marks have not been noticed in the present area, although they are abundant a short distance to the south of it.

The conglomeratic phases are chiefly remarkable for the numerous and often large pebbles of quartz they contain. Quartz pebbles, often 2 or 3 inches in diameter, are always in excess of other kinds and not uncommonly alone present. They are cemented by ordinary feldspathic quartzite.

Microscopic Description.—The purest quartzite examined is composed wholly of well worn quartz grains of uniform size, corresponding to fine sand particles. The individual grains have in some cases become enlarged and interlocking, but, in general, cementation is not very marked, and the spaces between the grains are filled with finer dusty looking matter—mostly decomposed feldspar and iron oxide. Feldspathic varieties and arkose contain somewhat more angular particles of quartz, orthoclase, microcline, and acid plagioclase. In specimens not collected from immediately at the surface or from shear zones the feldspars are not greatly altered. Shearing or squeezing is accompanied by the appearance of sericite at the expense of feldspar, the quartzite becoming more or less schistose. Metamorphism of this sort is, however, of very local occurrence and never highly developed.

Relations to the Cobalt Series and Older Rocks.

The strata of the Lorrain and older Cobalt series lie in the same positions. There is no such striking discordance as that between the steeply tilted Keewatin schists and flat lying Huronian sediments. Moreover, the Cobalt series contains impure quartzites, quite like those in the upper series. Hence the unconformity between them is not a conspicuous structural feature.

It was first discovered near Cobalt in 1905 by Miller.[1] A single outcrop was found in which arkose overlay and filled crevices in a fractured greywacke, besides containing a few angular blocks of the latter. During the season of 1910, Burrows[2] discovered two similar

[1]W. G. Miller, Ann. Rept. Bureau of Mines (Ontario), 1905, Pt. II.
[2]A. G. Burrows, Map of Gowganda Silver Area, 1910.

evidences of unconformity near Gowganda, which he describes as follows:—

'An unconformity was found on the north line of mining location H.R. 311, west of Obushkong lake, between a greywacke conglomerate and an overlying arkose series which has a few feet of quartz conglomerate at its base. In the basal material are a few fragments of the underlying greywacke. A somewhat similar unconformity was found near the south line of H.S. 712, near Flanagan lake, in Leith township.'

Mr. T. L. Tanton, one of the writer's party in 1910, found in the drift covered part of Brewster township blocks of impure quartzite containing angular pieces of banded slate like that of the Cobalt series. Mr. J. R. Marshall, of the same party, found banded slate and quartzite within a few feet of each other, the quartzite uppermost. Soil covering hid the actual contact, but no sign of transition from one formation to the other and no basal conglomerate in the quartzite were observable. Similar conditions were also found farther south in Gamble township. In other places no unconformity has been discovered, and there appears to be a transitional change.

In the southern part of Lawson township Lorrain arkose overlies Laurentian granite directly. The actual contact is hidden by drift, but the two formations occur only short distances apart. If the older series of sediments ever existed in this locality they were completely eroded before the arkose was laid down, and its absence may mean that the unconformity between Cobalt and Lorrain series is more important than might be inferred from its otherwise inconspicuous expression. On the contrary, it is perfectly possible that the lower series, being a continental deposit, never entirely covered the crystalline basement.

Structural Features of the Huronian.

The upper and lower series have endured the same general movements and have been disturbed, therefore, in like manner. Regional disturbance is confined chiefly to easy doming and folding of the strata along axes varying in direction from north-south to northeast-southwest. In the extreme northwestern part of the area, in Raymond township, the beds dip 15° west, but apparently the arch of a north-south anticline occurs in the same vicinity, for

between there and Duncan lake the dip becomes easterly and persists about half way across the district, though it decreases from 25° or 30° to anywhere between 15° and 0°. The central part—a strip about 12 miles wide extending from Nicol and James townships southwestward to Corkill and Wallis—is flat or domed so gently that the dip does not often exceed 10°, though it varies much in direction. East of this the strata assumes a westerly inclination, which increases to 25°, and produces the great north-south ridge called Maple mountain, which extends from the northern side of Banks township southward to Lady Evelyn lake, a distance of 15 or 20 miles.

The easy attitudes induced by folding have been interrupted locally in a manner suggestive of faulting. Along the West branch below Wapus creek the dip and strike of the slate are constant to a point where the river's course changes to due east. On this eastward stretch, however, the same rocks dip very steeply toward the s uth and the strike coincides with the course of the stream, that is, at right angles to its direction farther up stream. In equally abrupt fashion, flat-lying slate on the west shore of Firth lake assumes in one place a dip of 60° to 80°, striking south 30° east. The conglomerate at the Blackburn mine, that ordinarily dips very gently, becomes in a distance of 100 yards across the strike nearly vertical and somewhat schistose. Similar sheared bands have been noticed on Elkhorn lake and Great Bear lake. A more sharply defined fault, apparently later than the diabase, exists at the north end of Hanging Stone lake, the formation on the west side of it being greywacke and that on the east diabase. The repetition of conglomerate beds observed in the west, where the dip is greatest, may be a result of faulting.

Conditions of Huronian Deposition.

Cobalt Series.—Except for the rhyoli hat occurs in the southwest, the Cobalt series is purely sedim tary. It is, moreover, entirely clastic, and, so far as determinable, was derived from rocks similar to those in the underlying crystalline basement. At least a considerable part of it was deposited in water, but the resultant assortment and other depositional characters are so inconstant as to indicate that conditions during deposition were not uniform. The conglomerate furnishes good evidence of this lack of uniformity.

It frequently consists of water-worn pebbles held together by a clean, cross-bedded sand, all of which is suggestive of wave action, but it may, at no great distance away, possess a slaty or greywacke cement. It is unlikely that the original mud now represented by the banded slate cement endured protracted wave action, for material so fine would have been carried away from the boulders it encloses. It is stratified, in a regular and delicate manner which appears capable of only one interpretation: that it was deposited by periodic currents of water of brief and nearly equal duration. And it is scarcely possible that water was the sole transporting agent, for a current capable of carrying the pebbles 6 inches in diameter which lie embedded in the slate would have destroyed the delicate stratification in the latter when it was a mud. The only homologous structure known to the writer is that found in the pleistocene Saugeen clay near Lake Timiskaming, where occasional large pebbles are embedded in firmly laminated clay which is believed to have been laid down in a glacial lake. In this case the pebbles are believed to have been dropped from masses of floating ice, and a like explanation seems unavoidable in accounting for the granite pebbles in the Huronian slate. Where greywacke forms the conglomerate cement the pebbles are generally very few, and occur at intervals up to a yard from one another in a poorly assorted greywacke in which stratification is indistinct or not recognizable. It remains to be proven that the greywacke or greywacke conglomerate is water deposited; Coleman has drawn attention to its resemblance to boulder clay and to the South Africa Dwyka formation which is generally regarded as a consolidated boulder clay.

The succession of the Cobalt series is not so uniform as that which characterizes sea-deposition. There is a basal conglomerate and one higher up in the series, but the intervening greywacke, slate, and quartzite do not maintain any definite successional order. There are no limestones. The conglomerate and greywacke are poorly assorted. Abundant evidence exists of shallow water and local currents, during deposition of the conglomerate and banded slate, while the greywacke appears unstratified in places. The thickness of the basal conglomerate considered in conjunction with the fact that it was deposited upon a nearly horizontal surface, may also imply terrestrial development; Barrell is inclined to believe that marine conglomerates do not often exceed 100 feet in vertical thickness.

Since the Huronian strata are only gently folded, it may be assumed that little disturbance has taken place since their deposition and that, therefore, the pre-Huronian surface was as nearly a horizontal plane as it is now. And this condition is believed to obtain for a considerable distance in any direction from Gowganda district. If it does, there was no strong topographic relief and no neighbouring highlands in this region during Huronian time to account for the rapid disintegration which produced the detritus forming the Cobalt series. For certainly disintegration seems to have been much more rapid than contemporaneous weathering. The Laurentian beneath the Cobalt series has been seen in two localities and found to be quite as fresh as at the present surface. The coarseness of most of the Cobalt sediment, especially the great masses of conglomerate, also implies active disintegration, and it has been remarked already that feldspar particles in the greywacke are surprisingly clear and undecomposed. It is, therefore, necessary to conceive an erosive agent which was not dependent for its effectiveness upon topographic relief. Also a transport agent equally independent, for in the conglomerate both Keewatin and Laurentian boulders are mingled together whether the underlying formation be one or the other, and such mingling would scarcely take place without considerable travel. Some of these boulders are 5 feet in diameter and have travelled at least several—in one case 5—miles.

The only constructive hypothesis to explain the existing conditions has been advanced by Coleman.[1] He considers the Cobalt series to be of glacial origin, the greywacke and greywacke conglomerate being consolidated boulder clay, in proof of which he has found striated pebbles in the latter. It can be seen at once that the undecomposed nature of the Laurentian rocks underlying the sediments, their peneplanated and, in places at least, polished surface, and most of the other peculiarities here recorded are readily explicable upon this assumption. But Miller[2] found contacts between Keewatin schists and a Huronian breccia near Lake Timiskaming, where the fragments in the latter were evidently derived in situ. He also calls attention to the fact that glacial striæ have not been found upon the pre-Huronian floor, and that striated boulders, unless very wide-spread, do not necessarily imply glaciation.

[1]A. P. Coleman. The Lower Huronian Ice Age. Jour. Geol., Vol. XVI.
[2]W. G. Miller, Ann. Rept. Bureau of Mines (Ontario), 1907, Pt. II, p. 48.

It seems probable that the series is terrestrial rather than marine in origin and that, in part at least, it was laid down in shallow water. Also that floating ice helped to carry some of the conglomerate pebbles. It is not proposed to push conclusions further than this; nevertheless it must be granted in favour of glacial origin that many of the field facts harmonize with this assumption, and that no satisfactory alternative hypothesis has been advanced.

Lorrain Series.—On the east side of Lake Timiskaming, Barlow[1] discovered a transitional change from Laurentian granite upward into arkose, indicating the latter to have originated in situ. Near Cobalt, Miller[2] found quartzite filling crevices in an underlying Cobalt greywacke, and from consideration of this relation and the character of the quartzite, suggests that desert conditions may have prevailed there at that time.

In Gowganda district the Lorrain quartzite becomes thicker and more extensive toward the south and southeast, and successively higher horizons are reached by proceeding in that direction. What little is known about its contact with the Cobalt series reveals locally unconformable conditions like those found by Miller, the unconformity being marked by a thin conglomerate or breccia. The lower part of the formation as seen in Lawson, Trethewey, and adjacent townships, is feldspathic. But the higher portions farther to the south are more purely quartzitic and include chert and limestone. The stratification is also distinct, and accompanied by ripple marks and cross-bedding. Practically all the pebbles in the conglomeratic phases in any part of the formation are of quartz, as if other softer materials had succumbed to protracted wear. The stratification, cross-bedding, ripple marks, thorough assortment and presence of chert and limestone, the thickness of the series and its uniformity over a large area, seem to imply that its upper portion was laid down in a large body of water. The lower portion may have developed under the same conditions as near Lake Timiskaming, and yet upper and lower portions are not so different in character as to indicate that the latter was not also water deposited.

[1] A. E. Barlow, Ann. Rept. G.S.C. [illegible] 7.
[2] W. G. Miller, Ann. Rept. Bureau [illegible] ines (Ontario), 1907, Pt. II.

QUARTZ DIABASE

In Gowganda district quartz diabase occurs in dykes or large masses of laccolithic nature. The dykes vary greatly in size. The smallest one observed was one foot wide; large ones attained 150 feet. They are very numerous and so far as yet known of no economic interest, hence no serious attempt has been made to map them and their lengths are imperfectly known. In a few instances large dykes have been traced for half a mile without encountering any signs of termination. Wherever exposed in hillsides they are vertical, or nearly so, and vertical positions are probably the rule. Equally pronounced is a tendency to inhabit the crystalline basement rather than the sedimentary mantle. The Keewatin schists northeast of Gowganda are cut by a great number of dykes, though not many are found in the Huronian near by. An equally large number traverse Laurentian granite near Zigzag lake, in Morel township, though the adjacent Huronian formation is almost free of such intrusions. This preferential habit is also observable in other localities.

Compared with the dykes, the laccolithic bodies are of great size, though in this respect they also possess considerable variety. The sill near Davidson lake, in Haultain township, is only 50 feet thick in places. The Duncan Lake sill is 350 feet thick at a point near the outlet of the lake. Judging from the topographic relief and the depth of the mines, the diabase sill near Silver lake is at least 500 feet in thickness. The present areal distribution of the sills does not indicate their total present or original extents. Portions of them are still buried under Huronian beds and other portions have been completely eroded. As the silver-bearing veins are found within or near diabase sills, some interest attaches to the study of any structural features that may throw light upon the forms and original sizes of these intrusive bodies. The evidence bearing upon these points varies so much locally that each of the several isolated diabase areas requires individual description:—

Maple Mountain Area.—From near the northwest corner of Lady Evelyn lake a belt of diabase can be traced for 11 miles northward along the side of Maple mountain to a point half way along the eastern side of Banks township; thence it turns southwest, extending across Bear lakes. The area so outlined forms a huge V 10 miles long with apex pointing northeastward. Its eastern limb

presents clearly the relationships of a sill, being both overlain and underlain by quartzite with the bedding of which it conforms. At Darby lake it dips 25° westward under Maple mountain. The other limb comes to the surface, and in conformity with the steadily decreasing dip of the quartzite, becomes more nearly horizontal in its western part. On Little Bear lake and in the southeastern corner of Wallis it is flat lying, and worn so thin that only a few irregular patches are left resting on the quartzite. These remnants occur at brief intervals across Wallis and Trethewey townships, and may even have been continuous once with the similar flat-lying vestiges scattered over Brewster and Corkill townships. In the last named localities the diabase stands high topographically, forming caps on the hills, and it so happens in Corkill township, which is heavily drift covered, that only these hill tops reach above the soil burden.

Elk Lake Area.—A continuous diabase sill worn by erosion into highly irregular outlines, extends over portions of Barber, Tudhope, Smythe, James, Willet, Nicol, and Farr townships. This body, as its shape and great extent would indicate, lies nearly horizontally. Its southern lobe extending into Willet rests upon either Huronian or Laurentian rocks, and has been so deeply eroded that only the hills and higher ground are composed of diabase, while arkose or granite appear in the valleys. Some of the hills in this neighbourhood consist of quartzite, capped horizontally by diabase. On the northern side, Mr. Knight finds it resting upon the same rocks. Examination has not been close enough to decide whether it arches over the Huronian of James township or passes beneath it, that is whether the scattered patches of diabase in this interval represent vestiges of the base of the sill resting upon the sedimentary rocks or portions of its upper surface visible through holes in a sedimentary covering. At Silver lake, however, it is overlain by quartzite and dips southwestward.

Stony Lake Area.—A smaller, horizontal body of diabase, about 6 miles in length, rests upon Huronian and Laurentian rocks in Shillington township and northward.

Gowganda Area.—The diabase areas in proximity to Miller and Gowganda lakes are parts of one large sill-shaped mass that is over 20 miles in length, and underlain by Keewatin schists and Lauren-

tian as well as the Huronian. An elongated portion that extends from Nicol to the north side of Morel township shelves gently and conformably eastward under Huronian slate and greywacke. It also disappears westward under the Huronian between Miller and Gowganda lakes. Connexion between this part and the area west of Gowganda lake is indicated along the north line of Nicol township by a number of erosion remnants resting upon Keewatin and Huronian formations. Sill relations between diabase and Huronian are particularly well shown in the middle of Milner township, where diabase surrounds an oval patch of sedimentary formation about 4 miles long. This patch appears to rest upon the diabase, which can be seen on all sides, and particularly well at the south, to pass conformably under it. The actual existence of diabase beneath this Huronian patch is further indicated by several big dykes that rise through it, and also, between Long and Boyd lakes, by bleached and spotted phases of the greywacke such as are found only at diabase contacts. A slender extension of the Gowganda sill runs from the south end of Gowganda lake as far as the middle of Charters township. Similar ones reach northward into Van Hise township. The gradually increasing tilt of the sedimentary formations from east to west finds expression in the shape of the diabase areas and even within the Gowganda sill itself. The eastern half in Haultain and Nicol, where the average dip of the adjacent Huronian is slight, is of irregular shape and about equidimensional. But in Milner the Huronian dip is greater, the diabase sill accordingly inclined more and outcrops obliquely in the form of narrow and approximately parallel bands.

Duncan Lake Area.—In the vicinity of Duncan lake the Huronian is still more tilted and the linear form of the diabase area still more decided. Throughout Raymond, Knight, and the northern half of Tyrrell, the Duncan Lake sill lies between beds that dip 30° east, and only an edge shows at the surface as a continuous slender ribbon. But in Tyrrell township it reaches down to the crystalline basement, becomes horizontal and assumes a broader form. Irregular patches of diabase recur at short intervals as far south as Shiningtree lake.

Reviewing the conditions observed in each of the foregoing areas, it may be seen that each diabase body is of tabular form; it conforms in its attitude with the adjacent Huronian strata, or with

the surface of the older basement, and in nearly all cases is covered at some points by the sedimentary series. They may, therefore, be regarded as sills. It is further noteworthy that all of them lie within the Huronian or between it and the crystalline basement, but not within the basement itself. In respect to habitat, they are directly opposite to the dykes; the latter, though present in the Huronian, are in far greater abundance within he basement. This dissimilarity of behaviour seems capable of explanation from mechanical considerations. The granites and schists in the basement fracture indifferently along any plane, or vertically in the plane of schistosity; the Huronian sediments separate with most ease along their bedding planes, which are never far from horizontal. The diabase magma appears to have risen through vertical cracks in the crystalline floor of the district, but upon reaching the sedimentary mantle found it easier, instead of continuing upward across the stratification, to lift the sediments hydrostatically and spread out beneath them or along their bedding planes—the planes of smallest cohesion—forming sills. The cracks in the basement are now occupied by dykes.

Lithological Character.

Macroscopic Descriptions.

Diabase.—There are no flow structures, vesicular cavities or other evidences of extrusive origin in the diabase. Wherever it occurs it is a massive dark grey rock of typical diabasic appearance. It does vary, however, in coarseness as a result of the circumstances of its intrusion. Where the diabase magma forms a dyke only a foot wide, cooling took place rapidly, the time allowed for crystallization was correspondingly brief and a dense black basalt resulted, so fine-grained that crystalline texture is not perceptible. The great sills, on the contrary, cooled slowly, crystallization was made deliberate, and coarse-grained wholly crystalline diabase formed. Very commonly the augite and feldspar crystals composing sill diabase are a fourth of an inch in diameter, their coarseness earning for the rock the field name, gabbro. Exceptionally coarse-grained patches occur locally in which the individual crystals are an inch or an inch and a half long. Between the coarsest and finest varieties there are, of course, all intermediate gradations, since the intrusive bodies range widely in size. Dykes,

even large ones, possess considerable uniformity of texture, but the sill rock often changes suddenly from medium grained to very coarse phases and vice versa.

Red Rock.—There is sometimes associated with sill diabase, but apparently never in the dykes, patches of a dull red rock of syenitic appearance, which has been descriptively termed red rock. Red rock is greatly inferior in quantity to diabase. It is as coarse grained as the average sill diabase but richer in feldspar, which, instead of being light grey like that of the diabase, is dull red, and imparts to the rock its distinctive colour. Close inspection also reveals, in addition to the stout grains of augite, another dark constituent with the platy habit of mica. These distinctions between the two rocks are not always so pronounced, however, for usually one merges almost imperceptibly into the other. The red rock crystallized at [illegible] same time as the diabase and is not sharply separable from it, but occurs in vaguely defined patches of various sizes. In one [illegible] specimen of diabase contains numerous salmon-red [illegible] eighth of an inch in diameter, that give the rock a brilliant mottled coloration. At the other extreme, bodies of red rock several hundred feet in length and of considerable thickness exist on the shore of Gowganda lake, just west of the large island. In this instance and a majority of others that have been recorded, the red rock lies near the upper surface of a [illegible] sill.

Aplite.—The sills, but not the diabase dykes [illegible], are also cut by dykes of a light pink, finely [illegible] known as aplite. Such dykes are nearly always under [illegible] ugh a huge one in the neighbouring Cobalt area [illegible]. As a rule their walls are clearly defined and the [illegible] perfectly distinct. But this is not always true. In test [illegible] the diabase on the Lett property near Wapus creek, aplite can be seen to mingle irregularly with the diabase. The aplite is not uniform either in appearance or composition. An average specimen might be described as an unusually fine-grained pink granite poor in dark minerals, but there are wide variations from such a type. In its most basic phase it consists of red feldspar and an abundance of dark mica, the resultant colour of the rock being a dingy red like that of red rock. A very acid phase is nearly pure white, and consists wholly of white feldspars and quartz. Between these extremes there exists a complete series of intermediate varieties.

Aplite is prevalently light coloured and confined to dykes, while red rock is dark red and found in irregular masses within the diabase. This distinction is sufficiently general to be convenient for field use, but it disappears more or less completely where aplite dykes assume the same colour as red rock, or penetrate the diabase in the same irregular manner.

Microscopic Character.

Diabase.—Extreme variety in coarseness of texture, depending upon the size of the intrusive bodies and their respective rates of cooling, in a conspicuous microscopic feature of the diabase. The range in this respect is very great. All gradations are obtainable between dense black basalt to gabbroid diabase containing crystals of augite an inch in length. Basalt from the edge of a narrow dyke consists of a dark glass containing numerous small laths of labradorite and stouter prisms of augite (fig. 2, Plate III.) Very fine-grained diabase from a dyke 5 feet in width is holocrystalline, and composed essentially and in about equal parts of irregular augite grains and ophitically penetrating laths of an intermediate labradorite. Small angular interstices resulting from the ophitic arrangement are occupied by a little quartz. Titaniferous magnetite, also a little pyrite and chalcopyrite, occur in irregular grains within or near augite crystals. The only other accessory constituents are apatite, small rods of which penetrate both plagioclase and augite, and a rare flake of biotite. The average diameter of the plagioclase and augite crystals in such a specimen is 0·12 millimetres. There is little variation in mineralogical character among samples whose grain does not exceed 0·2 millimetres.

Increasing coarseness above 0·2 millimetres is accompanied by certain mineralogical divergences from the fine-grained specimen just described. The intermediate labradorite of fine-grained diabase becomes replaced by plagioclase of more variable composition, the range in coarse diabase extending from basic labradorite (Ab_{25} An_{75}) to andesine (Ab_{65} An_{35}). Also a new constituent appears: a micrographic intergrowth of quartz and acid plagioclase, which fills angular spaces among the augite and plagioclase crystals. Quartz and andesine are intergrown in the proportion of 40 and 60 per cent, respectively. The intergrowth makes its appearance in an interesting manner. Minute traces, in which the

micrographic structure is resolvable only by high magnification, are discoverable in fine to medium grained diabase. As progressively coarser diabases are examined the quantity of intergrowth steadily increases; likewise the size of the micrographic pattern. Gabbroid types contain 10 per cent or more of it so coarse as to be distinguishable without magnification (fig. 4, Plate III). The relationship existing between the amount of intergrowth present in any specimen of diabase and the coarseness of the diabase itself is expressed in Fig. 3. Crystals of titanite are found occasionally within areas of intergrowth, likewise in one thin section an irregular individual of calcite which, on account of the fresh condition of the enclosing minerals, is believed to be primary.

Red Rock.—When the ordinary plagioclase crystals of diabase attain the composition Ab_{65} An_{35}, they are optically identical with the plagioclase in the accompanying micrographic intergrowth. Under such circumstances the intergrowth is less strictly confined to angular spaces between the plagioclase and augite crystals, and may wander into euhedral plagioclase individuals of the earlier generation. At the same time there appear in association with it small crystals of titanite and flecks of yellowish-brown mica. With the appearance of these new minerals the feldspar of the intergrowth often becomes salmon-red, as seen in reflected light, though thin sections of it do not show any colour. In this manner diabase graduates into red rock. The brilliant mottling in a hand specimen described earlier is due to this change, commencing in spots through the diabase (fig. 5, Plate III). The term red rock is usually applied when the new mineral association—micrographic intergrowth of acid plagioclase and quartz, mica, and titanite—occurs in a pure state, or is so abundantly mingled with the diabase as to give it a uniform dingy red colour.

Under the microscope, well developed red rock consists largely of acid plagioclase, usually oligoclase, in rectangular crystal forms and also in intergrowth with quartz, though quartz is present in variable quantities, and may even be absent. The ferro-magnesian mineral is represented by chlorite almost invariably, though sometimes this can be seen to be the alteration product of another mica possessing the golden-yellow to brown pleochroic tints already described. It makes up one-fifth or more of the whole rock. Titanite occurs in small amounts either in crystals or irregular grains.

The black iron ore and sulphides found in the diabase are ordinarily present in small and variable quantities. Texturally, the rock is granitic rather than diabasic, feldspar alone exhibiting a porphyritic tendency.

Aplite.—When the diabasic mineral, black iron ore, disappears from red rock it is mineralogically identical with aplite. Aplite is an association of four minerals: acid plagioclase, quartz, mica, and titanite, usually accompanied by accessory apatite and sulphides. A thin section of average character (fig. 6, Plate III), consists of a rather fine-grained mosaic of plagioclase, quartz, and mica grains resembling a fine-grained granite. Plagioclase approaching albite in composition occupies about two-thirds of the entire section. A little of it is irregularly intergrown with quartz. The mica when fresh exhibits the same golden-yellow to dark brown pleochroic tints as in red rock, but is usually decomposed to chlorite. Titanite is of secondary importance, being represented by only a few small, rounded grains. Slender rods of apatite are fairly common, and a few irregular grains of chalcopyrite and pyrite can usually be found.

When aplite specimens from different dykes are compared they are found to differ from one another and from the description just given in a number of respects, most notably in the relative proportions of their essential constituents. Plagioclase and titanite are fairly constant in all cases, but the former varies in composition from andesine to albite; quartz and mica range from mere traces to one-fourth or one-third of the whole rock, and where one is abundant the other is correspondingly diminished. Aplite is not a rock of fixed composition, but variable within a certain range. At one extreme is a variety consisting of plagioclase, titanite, and a large percentage of mica, but no quartz; at the other, one of plagioclase, titanite, and quartz, but no mica, and between these lies an unbroken gradational series.

More than half of the material examined contains calcite. Sometimes this mineral is secondary, resulting from alteration in mica, but as aplite is seldom badly decomposed the quantity developed in this way is trifling. Most of the calcite has the appearance and relations of a primary mineral. It has no crystal form, but fills irregular spaces among the other mineral particles. The latter are fresh or too slightly altered to account for its secondary

origin. The percentage of calcite also is often too great to be accounted for as secondary. It ordinarily varies from a trace to 5 or 10 per cent, but the amount sometimes reaches one-fourth or more of the whole. In two instances: one in Haultain township, the other north of Shillington, an ordinary aplite dyke not conspicuously rich in calcite at most points was found to graduate into a calcite vein. When a calcite-rich specimen from the latter of these dykes was treated with hydrochloric acid until all the calcite had been removed, there remained a sponge-like mass of albite crystals, quartz, and chlorite weighing about half as much as the [illegible] mass.

[illegible] iron ore occurs sporadically in aplite. A majority of [illegible] contain [illegible].

Description of Minerals.

Pyroxene.—The chief ferro-magnesian mineral of the diabase is an augite of faint reddish-brown colouring in transmitted light. It does not possess crystal outlines except in incompletely crystallized basaltic rock types. Besides the usual good prismatic cleavage it exhibits parting parallel to the basal plane. Pleochroism is scarcely perceptible. By decomposition it invariably changes to a hornblende, distinguished by a strong blue-green pleochroic coloration in sections that show inclined extinction. A chemical analysis of a partly altered augite mechanically separated from diabase is given below. Medium grained diabase contains occasional large grains of pyroxene whose low birefringence and other optical properties agree with those of rhombic pyroxene, though the extinction is inclined as much as 10°.

Plagioclase. Orthoclase and microcline do not occur either in diabase or aplite; plagioclase is the only feldspar present. In the diabase it ranges in composition according to optical tests from Ab An, to Ab An, and occurs both in idiomorphic tabular crystals and in micrographic association with quartz. When in the latter condition it has an apparently constant andesine composition, and is distinctly later in generation than the more basic euhedral plagioclase. The plagioclase of aplite varies from Ab An, to Ab An, is of one generation and without good crystal form. The[illegible] is nothing unusual about the optical properties except

the refringence, which is abnormally low. The average refractive index of plagioclase, determined optically and chemically to [illegible] andesine, is nearly equal to that of the Canada Balsam, in which it is mounted, and lower than that of quartz. That this abnormal condition is due to the presence of some potash feldspar is indicated by the analysis cited page 70. Plagioclase in the diabase is white or grey. In red rock and the more basic aplite it is dull red, fading to pink and finally to white, with increasing acidity of the aplite. Bowen[1] ascribes this coloration to thin plates of hematite filling the cleavage spaces, an explanation which is supported by the iron content of the analysis. Basic varieties of the plagioclase alter principally to epidote, but those of andesine or more acid compositions develop shreds of colourless mica.

Quartz.—This mineral does not exhibit any peculiarities worthy of special mention.

Micrographic Intergrowth.—Micrographic intergrowth of quartz and plagioclase, though present in both aplite and diabase, is most perfectly developed in the latter. In aplite it is not distinctly separable from the ordinary granitic arrangement of quartz and feldspar grains, and its pattern shows considerable irregularity. In diabase, on the contrary, it is confined to sharply defined interstitial spaces and is more uniform in appearance. The plagioclase wherever determinable is an acid andesine, and apparently bears a constant quantitative relation to the quartz with which it is intergrown. Numerous estimates made by means of Rosiwal's method show the plagioclase and quartz to be present in proportions of nearly 60 and 40 per cent, respectively.

Mica.—Small and infrequent flakes of a reddish-brown biotite are present in diabase, the total content being extremely small. The ferro-magnesian mineral ordinarily found in aplite is chlorite, in black scales visible to the unaided eye. When magnified these are without crystal form, pale green in transmitted light, and show traces of the abnormal ink-blue interference tints of penninite. Occasionally the chlorite can be seen to be an alteration product of a yellowish-brown mica. This mineral is distinguished by an intense and rather unusual pleochroism: $\mathfrak{a}$ = pale golden-yellow; $\mathfrak{b}$, $\mathfrak{c}$ = dark greyish-brown. Its optic angle is very small, interference

[1] N. L. Bowen, Journ. Geol., Vol. 18

figures behaving like those on a uniaxial mineral. Pleochroic aureoles are visible in polarized light around inclusions of titanite. Enough sufficiently fresh materials for chemical analysis could not be obtained. This mica commonly consists of an aggregate of small shreds that give it the appearance of being secondary itself, but no evidence of development from another mineral could be obtained.

Iron Ore.—Analysis No. II page 70, of black iron ore separated magnetically from a sample of diabase, shows it to be a titaniferous magnetite. Good crystals are not often observable, but skeletal forms, showing the triangular lamellation of ilmenite, are not uncommon. Weathering produces an opaque white leucoxene.

Titanite.—Titanium, contained in the form of iron ore in diabase, finds mineralogical expression in aplite as small grains of titanite. This mineral is invariably present in aplite; it is also occasionally associated with the micrographic intergrowth in diabase.

Calcite.—As a secondary mineral, calcite is not found in diabase and seldom in aplite. The greater part crystallized as a primary mineral in aplite; it has been seen only once in diabase enclosed in an area of intergrowth. Crystal form is lacking.

Apatite.—Slender prisms of apatite are always present in both diabase and aplite to the amount of about one-fifth of one per cent.

Chalcopyrite and Pyrite.—Both these sulphides have been recognized. They occur regularly in diabase and aplite as scattered irregular grains and as fracture fillings.

Zircon.—A single small crystal has been found in one section of aplite.

Garnet.—A few small octahedra of a brownish isotropic mineral, probably garnet, were observed in one specimen of red rock.

	I.	II.	III.
SiO_2	48·00	9·34	67·76
Al_2O_3	4·31	2·77	17·86
Fe_2O_3	3·06	30·91	
FeO	17·34	31·16	1·60
TiO_2	0·91	17·40	
CaO	14·84	5·40	2·37
MgO	9·82	0·90	0·27
K_2O	0·15	......	2·48
Na_2O	0·91	.....	6·87
$-H_2O$	0·07	0·08	
$+H_2O$	1·00	1·29	
	100·40	99·75	99·21

I. Partly uralitized augite from diabase. M. F. Connor, analyst.

II. Black iron ore, slightly changed to leucoxene separated from diabase. M. F. Connor, analyst.

III. Plagioclase separated from an acid diabase. A. G. Burrows, analyst.

Quantitative Relationships of Aplite.

It has been seen that the relative proportions of the minerals that form aplite vary widely. The nature of these fluctuations was investigated more closely by determining the actual percentages of plagioclase, quartz, mica, and titanite present in a number of aplite specimens from different localities and comparing them. In most cases the volumes and masses of the minerals were determined from thin sections by employing Rosiwal's microscopic method. All available chemical analyses were also utilized by calculating them back into aplite minerals. The total data so obtained were arranged upon a rectangular diagram (Fig. 4), so that the percentages of each mineral are represented by vertical distances and the acidity

or silica content of each rock sample by horizontal distances. In so doing each specimen is regarded as an aggregate of four salts of silicic acid; horizontal distances on the diagram represent the total amount of acid radical present, while vertical distances give the quantities of each salt or mineral derived therefrom. For the sake of greater accuracy most of the silica percentages were determined by chemical analysis. When the points derived in this way were inspected, those representing any one mineral were found to be distributed in distinctly linear fashion. It was possible to represent each row of points by smooth curves which express fairly closely the proportions of plagioclase, quartz, mica, and titanite to be found in any form of aplite.

This is true for aplite containing only these minerals and negligible amounts of apatite and sulphides. It is not true upon direct consideration for calcite-bearing aplite. Specimens of this sort were analysed in the manner described, and an attempt made to represent the calcite contents by means of a curve but without success. No relation between the quantities of calcite and any of the other constituents could be discovered. But, when the calcite present in any case was excluded from consideration and the remaining minerals recalculated to 100 per cent, they were found to be in the same proportions as in calcite-free aplite.

Two samples of red rock were investigated, and found to behave quantitatively as ordinary aplite or basic or intermediate composition, the similarity being complete when the magnetite present in each was eliminated. There appears to be no doubt that red rock and aplite are identical. They are mineralogically and chemically alike and their relations to the diabase are the same. The distinction between them is one of degree only, red rock being a convenient field designation for irregular masses of reddish aplite that are not sharply definable from the diabase, and aplite for what is more commonly lighter in colour and has escaped into fissures to form dykes.

Largely through the work of Mr. N. L. Bowen,[1] a sufficient number of chemical analyses are now available for the composition of the aplite series to be expressed chemically as well as mineralogically. In Fig. 5 aplite is again regarded as an aggregate of several salts of silicic acid. Chemical analyses are so indicated that horizontal distances represent the amounts of silica present in each instance, and corresponding vertical distances the amounts of each

[1] N. L. Bowen, Journ. Geol., Vol. 18

oxide combined with it. In those analyses where CO_2 is present, the original calcite is calculated, deducted, and the remainder recalculated to 100 per cent. The comparatively smooth interpolated curves obtained in this way are entirely in agreement with the curves representing mineralogical composition. It must be concluded that, both chemically and mineralogically, aplite has varied or differentiated in a perfectly definite manner, in consequence of which its essential constituents bear definite quantitative relations to one another. It constitutes a series containing from 50 to 80 per cent of silica and graduating in the manner shown in Fig. 4, from a quartzless variety consisting essentially of 66 per cent andesine, 3[illegible] per cent mica, and 1 per cent titanite, to one consisting of 58 per cent albite, 40 per cent quartz, and 1 per cent titanite.

Quantitative Relationships of Quartz Diabase.

As soon as the quartz diabase is inspected quantitatively, a succession of anomalies reveal themselves. Chemical analyses, of which a considerable number have been made, prove it to be a basic rock containing from 48 to 52 per cent of silica. Quartz is an unusual constituent in rocks of such composition. If not entirely absent it is of only accessory importance. But in the present instance it forms as high as 5 per cent of the total. Again, the specimens richest in quartz might naturally be expected to be most acid, but this is not true. A specimen yielding 48·15 per cent SiO_2 contained 4 per cent of quartz, while another with 51·85 per cent SiO_2 contained only 2·5 per cent of quartz, and one with 50·56 per cent SiO_2 shows practically none. Similarly when the plagioclase ranges from Ab_{25} An_{75}, to Ab_{65} An_{35}, its calcic varieties might be anticipated in basic diabase and sodic ones in acid diabase. But of two specimens, each containing Ab_{35} An_{65}, one yielded 52·05 per cent, the other 48·15 per cent SiO_2; another containing Ab_{65} An_{35}, yielded 51·34 per cent. It is further notable that fully half the analyses of diabase show over 50 per cent of silica, a quantity which exceeds that of basic aplite.

These abnormalities are most evident in coarse-grained diabase from sills and the middle portions of large dykes. Fine-grained material is more constant in character. It consists uniformly of augite, plagioclase, magnetite and accessory apatite, sulphides, and

biotite. Micrographic intergrowth is absent or nearly so. The proportions of plagioclase, augite, and magnetite in different samples of fine-grained diabase have not been carefully compared, but from ordinary comparison of thin sections they do not vary appreciably. Plagioclase varies little in composition from basic labradorite. The chemical composition of such a fine-grained diabase from a narrow dyke is given in No. I of the table of analyses below.

Apparently the original magma, as represented by such finely crystalline, quickly cooled rock, was of homogeneous character. Notable variations and abnormalities are found only in more coarsely crystalline slowly cooled phases. It might, therefore, be expected that, by comparison of a suite of specimens representing successive stages in cooling, the inception and development of these variations might be observed. When, to test this possibility, samples from the edge and middle of a dyke 60 feet wide cutting the Huronian greywacke were compared they w re found to differ in coarseness and in one other respect: the presence of micropegmatite. This constituent formed 3·64 per cent of the coarser specimen from the middle, but could not be seen in the finer peripheral one. All available thin sections, whether from dykes or sills, were then compared, and it was found that micropegmatite was absent or occurred as mere traces in the fine-grained diabase, but was invariably present in coarse-grained specimens and in considerable amounts. These amounts were determined in a number of instances by employing Rosiwal's method, the corresponding average size of grain of the specimens measured and the results graphically correlated (Fig. 3). It was found thus that the intergrowth does not appear before a certain coarseness of grain has been attained, and then increases in approximately direct proportion until the diabase becomes of gabbro-like coarseness. As coarseness of grain in different parts of the same rock bears a nearly direct relation to its rate of cooling, the quantity of micrographic intergrowth present in the quartz diabase is also in similarly direct relation to the rate of cooling. Divergences from proportionality grow more pronounced in coarse[illegible] diabase.

From its wide-spread and tolerably uniform distribution throughout every sill and dyke of considerable size, it is highly probable that the micropegmatite was an original constituent of the diabase magma. Its peculiar quantitative relation to the rate of cooling

reveals, therefore, a tendency for part of the magma to separate in this form, more or less completely, according to the time available. It is conceivable that under suitable conditions the micropegmatite would separate completely and by virtue of its low density escape from the rest of the magma. To estimate the results of such an event, four coarse-grained specimens were selected in which the

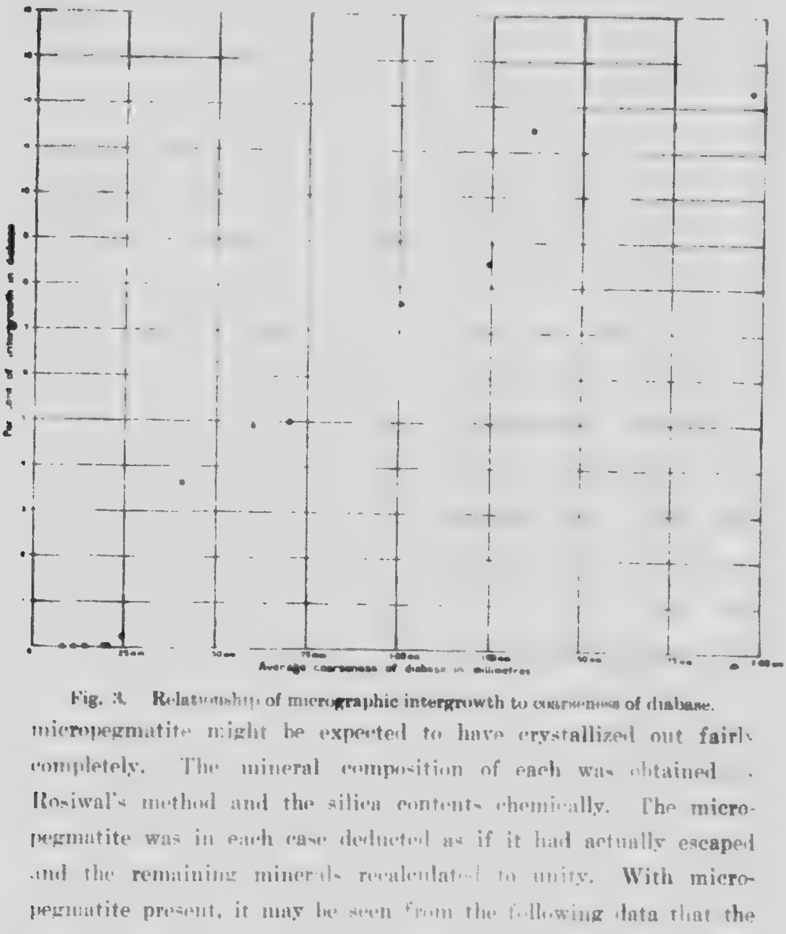


Fig. 3. Relationship of micrographic intergrowth to coarseness of diabase.

micropegmatite might be expected to have crystallized out fairly completely. The mineral composition of each was obtained by Rosiwal's method and the silica contents chemically. The micropegmatite was in each case deducted as if it had actually escaped and the remaining minerals recalculated to unity. With micropegmatite present, it may be seen from the following data that the silica contents are in rather contradictory relation to the quartz contents and composition of the plagioclase, and that in three of the

four cases the diabase is as acid as aplite. After subtracting the micropegmatite there remained:

Samples.	Silica.	Quartz.	Plagioclase.	Intergrowth
	%	%		%
1	48·15	4·20	Ab[illegible], An[illegible]	8·48
2	50·81	5·20	Ab[illegible], An[illegible]	11·44
3	51·34	3·85	Ab[illegible], An[illegible]	7·62
4	52·05	5·47	Ab[illegible], An[illegible]	12·51

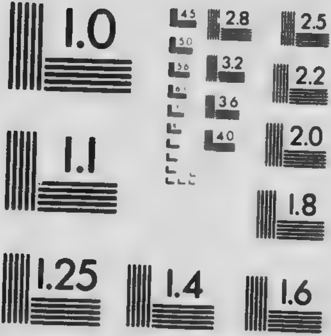
In each case a mineral association of augite, plagioclase, and iron ore such as constitutes an ordinary gabbro. The silica contents were reduced to between 45 and 50 per cent, in no case exceeding that of aplite. The relative amounts of anorthite and albite composing the plagioclase were then in the relation to total acidity that characterizes igneous rocks on the whole. Briefly, by removal of micropegmatite, somewhat anomalous quartz diabases were transformed into normal quartz-free diabase.

The quantitative relations of augite, plagioclase, and iron ore to total silica in these four cases are expressed in Fig. 4, and exhibit a tendency on the part of micropegmatite-free diabase to differentiate into a basic to acid series analogous to the aplite series. The variation of plagioclase between bytownite and andesine indicates that such a differentiative process has been active, but the data at hand are much too scanty to infer that the curves of Fig. 4 represent more than approximately the course of this process. In fact later work shows that the iron ore does not associate in such definite proportions with the silicate constituents as indicated.

It is implied that micropegmatite tended, during solidification of the diabase, to separate from the remainder of the magma, leaving a normal diabase which differentiated into an acid to basic series. The best proof of this would be to find a normal intergrowth-free diabase corresponding in composition to some part of the diabase series as it is graphically represented. Such a diabase has not been recorded, with the possible exception of a specimen analysed by Mr. J. O. Handy (Table of analysis below, No. III), which is described as a gabbro containing no quartz. It is somewhat interesting to

MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)



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note, also, that near Lake Nipigon, where there are diabase hills of much greater extent than those in Gowganda district, the sill rock is a normal quartzless diabase, while dykes 200 feet wide associated with it contain a quartz diabase indistinguishable from that under consideration.

Analyses of Diabase and Aplite.

	I.	II.	III	IV.	V.	VI.	VII.	VIII.	IX.
SiO_2	50·76	50·12	48·06	51·41	54·34	62·54	58·84	72·33	78·28
Al_2O_3	13·90	15·70	18·23	14·13	16·90	14·79	11·24	12·99	12·00
Fe_2O_3	4·13	1·42	9·57	3·48	1·65				
FeO	10·28	6·89		9·25	6·76	8·49*	0·47	2·50	1·19
CaO	8·14	11·30	11·55	6·40	1·29	1·49	12·17	1·73	0·29
MgO	4·73	9·50	7·80	5·54	4·51	2·08	0·35	0·97	0·37
Na_2O	2·82	2·91	1·87	3·43	8·02	6·27	6·91	7·60	6·89
K_2O	0·85	1·07	0·27	1·80	0·55	1·12	0·07		tr.
$+H_2O$	1·57	1·24	3·54	1·98	4·22	3·51	0·40	1·09	0·61
$-H_2O$	0·23			0·12	0·18				
CO_2							9·84	1·00	none.
TiO_2	1·50	0·55		1·20	1·24	0·26	0·74	0·34	
CoO and NiO	none.								
P_2O_5	0·07			0·06	0·12				
MO	0·34			0·30					
Total	99·32	100·70	99·83	99·10	99·78	100·29	100·68	100·95	99·97

* 3½ per cent magnetite in thin sections.

I. Fine-grained diabase without micrographic intergrowth, from a dyke in Rankin township. M. F. Connor, analyst.

II. Medium-grained diabase with little micrographic intergrowth, from Cobalt. N. L. Bowen, analyst. (Journ. of Geol., vol. 18.)

III. 'Gabbro,' without quartz, from Cobalt. J. O. Handy, analyst. (Ann. Rept. Bureau of Mines, Ontario, 1905, pt. II.)

IV. Coarse-grained quartz diabase containing an andesine feldspar, from Wapus creek. M. F. Connor, analyst.

V. Aplite from Lett property, Wapus creek. M. F. Connor, analyst.

VI. Red rock from Lost lake. N. L. Bowen, analyst. (Journ. of Geol., vol. 18.)

VII. Aplite from James township. N. L. Bowen, analyst. (Journ. of Canadian Mining Institute, vol. 12.)

VIII. Aplite from Cobalt. N. L. Bowen, analyst. (Journ. of Canadian Mining Institute, vol. 12.)

IX. Aplite from James township. N. L. Bowen, analyst. (Journ. of Canadian Mining Institute, vol. 12.)

Metamorphism.

Existing conditions at diabase contacts indicate that its intrusion was accomplished with but slight deformation and alteration of the older formations. As a rule contacts with the Huronian are marked by narrow ravines formed on one side of undisturbed and unaltered sedimentary strata and on the other by diabase. The bottoms of the ravines are so filled with soil and talus blocks that the immediate contact cannot be seen. But in a few more favourable localities where the contacts occur on hillsides the diabase and, to a less degree, also the sedimentary strata can be seen to be fractured for some feet or yards away from the plane of contact. This fractured zone is more susceptible to erosion than the unbroken formations on either side, and probably gave rise to the contact ravines.

When the sediments can be traced all the way to the contact they usually show little or no disturbance, but in some places they become imperfectly schistose and their bedding planes grow obscure and irregular for some feet or yards away from the diabase. Angular blocks are occasionally broken off and enclosed by the diabase. Jointing is the only notable feature presented by the intrusive rock. On Big Bear lake, where erosion has left only scale-like vestiges of the Maple Mountain sill resting upon quartzite, both diabase and quartzite show well defined partings parallel to their contact surface. The former separates into flakes so thin and uniform that, from a little distance, it resembles a flat-lying stratified formation. Columnar jointing is well developed in diabase cliffs near the Bonsall mine at Miller lake; also at Silver lake, where some of the columns are 15 feet in diameter.

Contact alteration appears to be confined to Huronian sediments. The effect of the diabase upon Keewatin schists has not been closely studied, but seems to be slight or nil. Laurentian granite shows no change. But a contact zone from a few inches to several feet, is recognizable in Huronian sediments, particularly greywacke, wherever they adjoin a diabase body of large size. Quartzite becomes glassy and more perfectly recrystallized. Within 6 inches of the diabase it is fused to a dense black material in which the larger unfused quartz grains are visible. At times this black material contains rounded, partly fused pieces of quartzite that bear a remarkable resemblance to conglomerate pebbles. Under the microscope the fused material appears as a dark grey glass filled with unfused particles of quartz. Flow lines are evident, and some of the unfused pieces of quartzite have been twisted and drawn out. Calcite is also fairly abundant and appears to replace, wholly or in part, some of the quartz grains. In a section showing the fused quartzite and diabase in contact, the line of division is perfectly sharp and the diabase presents no unusual features. Globules of diabase an inch in diameter sometimes find their way into the fused quartzite but remain distinct from it. They are medium-grained and contain no intergrowth or only small amounts of it.

Greywacke is usually bleached to a pale grey colour for a vertical distance of a yard or less away from the diabase, and becomes filled with black spots about a millimetre in diameter. Comparison of a specimen so affected with ordinary greywacke shows it to be somewhat more crystalline, and to consist essentially of a mosaic of quartz and feldspar grains, many of the latter being twins and near albite in optical behaviour. The black spots are due to irregular aggregates of chlorite. The change is largely one of recrystallization, the individuals being larger than in the original greywacke and the feldspars quite fresh and frequently interlocking with one another. Ordinarily the zone of alteration is narrow and composed of only the spotted greywacke. But at times, and apparently when in contact with diabase containing segregated masses of the reddish variety of aplite called red rock, alteration is more extensive, and the spotted greywacke is further changed to a reddish rock bearing some external resemblance to the red rock itself. This reddish alteration product is more coarsely crystalline than the spotted one. It consists essentially, however, of the same

mosaic of interlocking plagioclase and quartz grains. But the aggregates of chlorite in the latter have been dissipated and chlorite becomes somewhat less abundant. Calcite, on the other hand, appears in considerable amount and apparently not as an alteration product, for the plagioclase is not enough decomposed to account for it. Plagioclase is more abundant than in the spotted greywacke, its complexly interlocking individuals making up a large part of the rock. On the whole the greywacke exhibits a tendency to approach aplite in mineralogical character with progressive contact alteration, but, as the following partial analyses[1] of altered and unaltered greywacke show, the convergence is not complete:

	Ia.	Ib.	Ic.	IIa.	IIb.	IIc.
SiO_2	62·54	60·70	75·43	54·77	58·48	61·54
Na_2O	6·27	9·33	5·72	4·85	4·81	4·73
K_2O	1·12	0·43	0·21	3·50	3·11	2·64
CaO				0·65	1·08	0·84

Ia. Red rock, upper contact diabase sill, Lost lake.
Ib. Altered sediment in contact with Ia.
Ic. Less altered sediment.
IIa. Much altered sediment near diabase, Lily lake.
IIb. Less altered sediment near diabase, Lily lake.
IIc. Still less altered sediment near diabase, Lily lake.

Conclusions.—It seems possible to arrange the facts already given in an order that will explain consistently the sequence of events following upon the intrusion of the diabase magma.

To the best of present knowledge, the diabase magma was homogeneous at the time of intrusion for, wherever it was intruded as small quickly solidified bodies, that is, dykes, even though these be many miles apart, it gave rise to a fine-grained diabase of apparently uniform composition. The chemical composition is represented by analysis No. I of the preceding table, mineralogically by about 50 per cent of intermediate labradorite, slightly less augite, and subordinate amounts of iron ore, apatite, quartz, and sulphides.

Where cooling was slower, as evinced by the coarser crystallization, variations in composition appeared. The plagioclase became variable in composition, ranging from bytownite to ande-

[1] N. L. Bowen Journ. of Geol. vol. 18, Nov.-Dec., 1910.

sine; the proportion of plagioclase and augite also grew variable, the former increasing in quantity with increasing percentage of albite. Also a new constituent, micrographic intergrowth of acid plagioclase and quartz appeared. The quantity of intergrowth increased in approximately direct proportion with the rate of cooling. There are two possible explanations for this variation. Differentiation is involved in either. It might have been caused by differentiation within the magma alone, or by assimilation by the magma of the older rocks in contact with it and subsequent differentiation. It may be said in favour of the assimilation hypothesis that the fused quartzite and altered greywacke found in contact with diabase sills are strongly suggestive of assimilation, and in all probability some assimilation has taken place. But the contact zone is seldom more than a yard in width, and blocks that have been torn away from the older formation and enclosed in the diabase show little signs of becoming rounded and assimilated. All of which suggests the total amount of assimilation to have been small. Neither is there any apparent local enrichment of micropegmatite in their immediate vicinities. In fact, in the case of dykes, where there is no visible evidence of assimilation, micropegmatite is present and not peripherally as might be expected upon this assumption, but in the interior. The micropegmatite appears to be the same whether the adjacent rocks be Keewatin, Laurentian, or Huronian, though these differ widely from one another in character. It would also be necessary upon this assumption to believe that assimilation products had diffused throughout every mass for the intergrowth is present in all parts of the sills and larger dykes. It is not impossible that some of it has developed in this manner, but no conclusive evidence to this effect has been obtained, and the difficulties mentioned render it highly improbable that most of the widely disseminated intergrowth could have originated in this way. It seems much more reasonable to ascribe the intergrowth and other variations of the diabase to simple magmatic differentiation.

In this light the intergrowth must be considered to be an acid differentiate, and as such its quantitative relationship to the speed of cooling of the magma is at once explicable. Under certain conditions micrographic intergrowth assumes the character of aplite. When the containing diabase has reached its greatest observed acidity—indicated by the plagioclase being $Ab_{[illegible]}An_{[illegible]}$—it is

occasionally accompanied by calcite and titanite. Under the same conditions quartz may migrate into crystals of this plagioclase, accompanied by titanite and the peculiarly pleochroic mica which is found in aplite. The presence of these minerals is commonly indicated by the plagioclase being red instead of grey as in ordinary diabase. This new association appears irregularly or in spots in the andesine-bearing diabase (fig. 5, Plate III); when it has replaced the diabase it is given the name red rock. Red rock, however, is identical with aplite. Micrographic intergrowth, red rock, and aplite are, therefore, closely related to one another, and appear to be successive phases of one acid differentiate which separated as fully as the conditions of cooling permitted from another more basic portion of the original magma.

Segregation was more or less complete according to the rate of magmatic congelation. Interstitial quantities of intergrowth varying in size from microscopic to barely visible without magnification, resulted during solidification of dykes of various sizes; irregular spots and patches of red rock, from 1 cm. to 100 m. in diameter, and aplite dykes, developed during the more protracted cooling of sills. Perhaps there was some tendency on the part of the lighter aplite to rise toward the upper surface of the diabase, for a considerable number of aplitic bodies have been found in the upper portions of the sills, but the results of this tendency are not strongly in evidence.

Differentiation of diabase and aplite from one original magma was accompanied by differentiation within each of these derivatives. Aplite consists of a gradational series of rock type ranging in the manner indicated in Figs. 4 and 5, from a basic quartzless variety containing 50 per cent of silica and composed of andesine, mica, and titanite, to an acid one containing 80 per cent of silica and composed of albite, quartz, and titanite. Had separation of basic and acid derivatives been complete, a similar differentiation, whose approximate character is represented in Fig. 4, would probably be as evident in the diabase, but the vestiges of aplite left in the form of micrographic intergrowth have obscured the results of this process.

Calcite accompanies aplite as a primary mineral, but sporadically and in no definite proportions to the other constituents. Only

two possible sources are known. Owing to its irregular quantitative relation, it was first considered by the present writer to have been obtained from the older formations, particularly the calcite-rich Keewatin, by the aplitic fluid, but there are several difficulties connected with this assumption which render it scarcely tenable. As previously stated, there is but little evidence at contacts that the older rocks have been extensively assimilated. It is also true where quartzite has been partly fused for a few inches away from diabase contacts, that calcite is fairly abundant and replaces quartz, though carbonates are not observable in the fresh quartzite. Apparently there has been enrichment rather than diminution of calcite at the contact. Again, it is only less difficult upon this assumption to account for calcite a hundred feet or more within the diabase than to account for the wide-spread micrographic intergrowth.

It is also possible that calcite is native to the diabase, and by virtue of immiscibility with silicates, behaved as a third independent differentiate. Except that calcite has not been commonly recognized to originate in this way, there is apparently no objection to such an hypothesis. Its very existence as a primary mineral in aplite, and even in diabase, is sufficient evidence that it could and did exist at the crystallizing temperatures and pressures of these rocks. Its occurrence far within diabase sills and as replacements after quartz in partly fused quartzite would also be capable of a rational interpretation.

Reasons are given upon a later page for believing the silver-cobalt veins that are found in or near the diabase to be the last products of the differentiated magma.

The metamorphic effect of the intrusives upon slate and greywacke, so far as it is known, is in harmony with other observed facts. Contact alteration of these sediments must result either from introduction of material from the diabase or from loss of some of their own constituents through the thermal and solvent influence of the diabase, or from both these properties. The solutions given off by the diabase would contain such substances as did not readily take solid form while diabase was crystallizing, and would more closely resemble chemically the last known products of magmatic differentiation—aplite and vein materials—than the diabase itself. They might be expected, therefore, to carry soda, silica, and calcite or free CO_2, and in fact soda was introduced and calcite appears to

be, though the silica content of the greywacke decreases. Local conditions favourable for aggregation of aplitic masses would probably be favourable also for accumulation of still more fluid residual portions of the magma. Consequently where such aplitic masses occur at the surface of diabase sills the contact effects impressed upon the adjacent sediment would be unusually intense. Too few observations of this contact zone have been made to permit safe generalization, but in a few instances where sediments do lie against red rock instead of diabase they are altered to an unusual extent.

EXPLANATION OF PLATE III.

1. Banded Huronian slate cut normal to laminæ. X 8.
2. Basaltic phase of quartz diabase. X 9.
3. Medium-grained quartz diabase, with traces of micrographic intergrowth. X 9.
4. Gabbroid phase of quartz diabase. X 9.
5. Quartz diabase containing spots of aplite. X 9.
6. Aplite. X 9.

PLATE III.

Microphotographs:—(1) Banded Huronian slate cut normal to laminae, x 8. (2) Basaltic phase of quartz diabase, x 9. (3) Medium grained quartz diabase with traces of micrographic intergrowth, x 9. (4) Gabbroid phase of quartz diabase, x 9. (5) Quartz diabase containing spots of aplite, x 9. (6) Aplite, x 9.

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EXPLANATION OF FIGURE 4.

1. Rosiwal's analysis of diabase containing plagioclase of the composition Ab_{38} An_{62}, from Lett property, Tyrrell township.

2. Rosiwal's analysis of diabase containing plagioclase of the composition Ab_{45} An_{55}, from east side of Duncan lake, Knight township.

3. Rosiwal's analysis of diabase containing plagioclase of the composition Ab_{45} An_{55}, from Lett property, Tyrrell township.

4. Rosiwal's analysis of aplite, from York property, James township.

5. Rosiwal's analysis of aplite, from Mann property, Milner township.

6. Corrected Rosiwal's analysis of calcite-bearing aplite, from Lett property, northeast corner of Tyrrell township.

7. Rosiwal's analysis of aplite, from Mann property, Milner township.

8. Rosiwal's analysis of aplite of the variety called 'red rock,' from west shore of Northeast arm, Gowganda lake.

9. Rosiwal's analysis of aplite, from James township.

10. " " from west of Gowganda lake.

11. Recalculated from chemical analysis of aplite by N. L. Bowen.

12. " " " "

13. " " " "

14. Rosiwal's analysis of aplite, from H.R. 459, Van Hise township.

15. Rosiwal's analysis of diabase containing Ab_{35} An_{65}, from Cobalt.

[illegible]

[illegible]

[illegible]

[illegible]

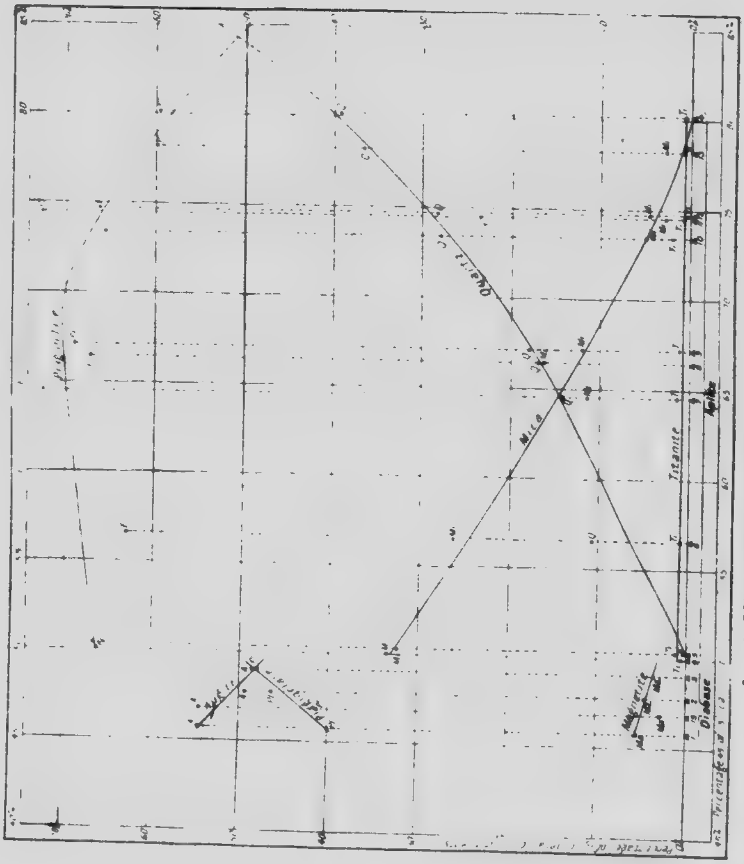

Fig. 4. Mineralogical differentiation of diabase magma.

EXPLANATION OF FIGURE 5.

1. See table of analyses, No. IV. Quartz diabase containing andesine and 7·62 per cent micrographic intergrowth. Intergrowth deducted; remainder recalculated to 100 per cent.
2. See table of analyses, No. V.
3. Table of analyses, No. VI. Red rock containing 3½ per cent magnetite. Magnetite deducted; remainder recalculated to 100 per cent.
4. Partial analysis of aplite from Gowganda lake, by M. F. Connor.
5. Analysis of aplite from Cobalt, by R. E. Hore, Econ. Geol., Vol VI, 1911, p. 54.
6. Table of analyses, No. 8. Calcite calculated, deducted, and remainder recalculated to 100 per cent.
7. Table of analyses, No. VII. Calcite calculated, deducted, and remainder recalculated to 100 per cent.
8. Table of analyses, No. IX.
9. Micrographic analyses of aplite consisting of quartz and albite.

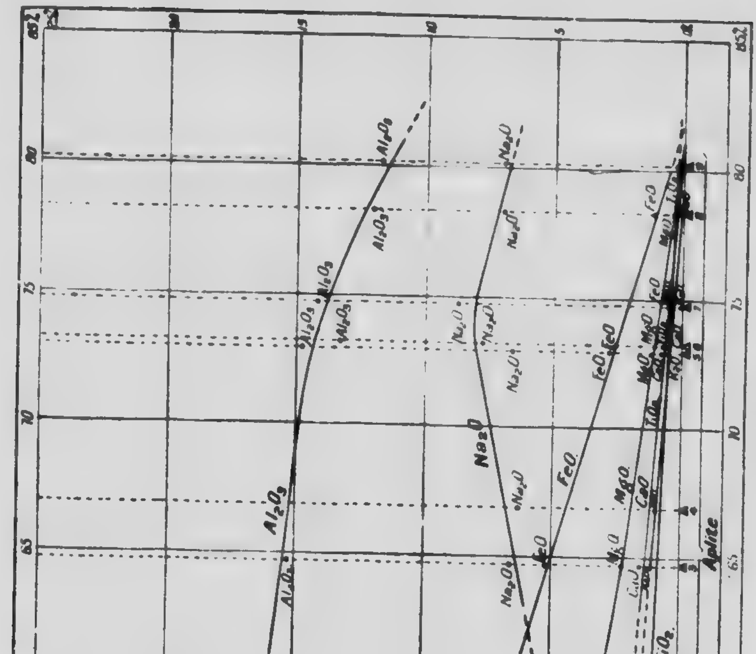

Fig. 5. Chemical differentiation of diabase magma.

OLIVINE DIABASE.

Distribution.—Although olivine diabase is not restricted to any one part of the district, its total exposed area is exceedingly small. What is shown upon the accompanying map, however, does not represent all for, owing to the small size of individual bodies, a considerable number have almost certainly been overlooked. Others have probably been mistaken for quartz diabase, which the olivine-bearing variety resembles. Most, and perhaps all of those found are dykes, which cut the Huronian and older rocks, but it is possible that some in the Huronian lie parallel to the stratification, like the quartz diabase sills. An unusually large body, 400 feet wide, lying near the west side of Willet township, may be of this sort. The quartz diabase near Miller lake is reported to be intersected by a dyke of olivine diabase, a relation which Miller has observed in Cobalt district.

Lithological Character.—Like quartz diabase, the olivine diabase varies considerably in appearance, depending upon the size of the mass it forms. A dyke of 17 feet wide was found to consist of fine-grained rock similar in colour to quartz diabase of like coarseness, but distinguished from the latter by slenderer, lath-shaped feldspar crystals. Larger bodies, such as that already mentioned in Willet township, contain a strikingly porphyritic rock consisting of abundant stout phenocrysts of feldspar in a diabasic groundmass, somewhat coarser but otherwise similar to the nonporphyritic variety. The phenocrysts attain diameters of 4 inches and when of this size occupy almost as much space as the groundmass. From the fact that phenocrysts are not present in the small dykes, it seems necessary to believe that they grew in the magma after the intrusion. They occur, however, in all parts of the larger dykes, though those near the edges are not as large as more centrally located ones.

A specimen containing no large phenocrysts was found to have a density of 2·99. Under the microscope it appears remarkably fresh, none of the constituents being decomposed. A labradorite of intermediate composition, twinned and commonly showing zonary structure, occupies two-thirds of the total area in these sections. It forms lath-shaped crystals that penetrate augite and olivine ophitically. These latter minerals are present in about equal

amounts, the former being similar to that found in quartz diabase, the latter optically negative and forming rounded or idiomorphic grains which are sometimes margined by small flakes of reddish-brown biotite. Black iron ore and apatite are accessory, though the long rods of the latter mineral are unusually numerous. There are also rare crystals of zircon.

The groundmass of porphyritic varieties answers this description fully. The phenocrysts are plagioclase and exhibit a prominent zonary structure. The average composition of the phenocryst plagioclase is about the same as that in the groundmass, but the zones alternate from fairly basic to acid labradorite. Small grains of augite and olivine are enclosed within the phenocrysts, chiefly in the outer portions of the latter.

Relationships.—In spite of its unimportant volume, the olivine diabase is very widely distributed. It occurs as far east as Cobalt. It is present throughout Gowganda Mining Division. An olivine diabase has been mapped by Burrows in Porcupine district, a long way north of Gowganda; this, while not necessarily identical with the olivine diabase under consideration, is at least post-Huronian. Walker[1] has in terms nearly identical with those applied here described a porphyritic olivine diabase which intrudes the nickel-bearing norite at Sudbury. 'A handsome diabase porphyrite containing large white crystals of plagioclase feldspar in a dark green groundmass' has been observed near Silver islet, Lake Superior, by Coleman.[2]

Even if identities do not exist in all these cases, it is still true that the olivine diabase under consideration is wide-spread and meagrely represented. Ordinarily dykes are associated with some larger parent mass. In this case the quartz diabase is the only important intrusion to which the olivine diabase dykes might be so related. No conclusive proof of such a relation is known, but in any case the relationship of the olivine diabase dykes to the quartz diabase would not be the same as that of the aplite dykes, for the latter have been differentiated since the quartz diabase intrusions, and are found only within that formation, while olivine diabase dykes occur in all the older formations as well and were, therefore, intruded independently.

[1] T. L. Walker, Quar. Journ. Geol. Soc., Vol. 53.
[2] A. P. Coleman, Ann. Rep. Bureau of Mines (Ontario), 1896.

PLEISTOCENE.

The glacial gravel and sand that rest upon the Pre-Cambrian rock surface are similar to those found elsewhere in northern Ontario, and require no lengthy discussion. They are unstratified and of irregular thickness, being practically absent over a considerable part of the district and over 100 feet thick in other parts of it. In general the western half and the eastern edge of the district are not so deeply covered as the central portion; the townships of Corkill and Lawson are largely covered by a sheet of drift which extends in the direction of Elk lake. The southern half of Leonard township is covered by part of another large drift area, the main part of which extends southwestward.

Glacial striæ upon the older rocks vary in course about 20 east or west of south. Glaciated boulders are wide-spread, and sometimes collected in what may have been former stream channels; small pot-holes were found in the Huronian rocks near one of these channels which lies a short distance south of the present district. Gravel ridges of winding ground plan were met in Shillington township. In Lawson and in Leonard townships there are a number of small but steep-sided depressions or kettle-holes on the drift, some of which contain small lakes without visible outlets.

Prospecting operations are hindered by the soil sheet, especially in Lawson and Corkill where only the highest portions of the Pre-Cambrian surface are visible, but this drawback is amply compensated, from a purely economical standpoint, by the influence of the soil upon vegetation. The best pine forests in the district grow in the soil-clad parts of Chown and adjoining townships. Although the soil is sandy and apparently not well suited for farming purposes, a luxuriant grass growth was observed in clearings made by forest fires.

AGE RELATIONSHIPS.

Sir W. E. Logan visited Lake Timiskaming in 1845, noted the existence of sedimentary rocks and an older gneissic formation, and applied to the latter the term Laurentian. Huronian did not come into use as a geological name until 1855. At that time the igneous nature of the Laurentian was not recognized. It was considered as the oldest of the Pre ... brian formations and the source of the materials composing w... was then called the Huronian but is now

subdivided into Keewatin and Huronian. Its intrusive character in western Ontario was proved about 1885 by Lawson, and the name Keewatin given to the schist complex intruded by it.

These relations were known when A. E. Barlow, in 1892, commenced the examination of an area of 7,000 square miles in Timiskaming region. For the northern half of this district Barlow established the same intrusive relations of the granites and gneisses to the adjacent Pre-Cambrian formations as those discovered by Lawson. He also noted, as Logan had done earlier, that a part of the latter also overlay the granite and had been derived from it. However, all the schists and Pre-Cambrian sediments were mapped as Huronian and the granites and gneisses as Laurentian, the only further subdivision being a distinction of the post-Huronian diabase. Barlow did further work in this district during 1903-5, and separated his older Huronian group into a Keewatin schist complex older than the Laurentian, and a Huronian series younger than it.

In 1905, W. G. Miller examined Cobalt district, a small portion of the same area covered by Barlow, in detail, and defined the geological succession as it is accepted at present. He found Barlow's lower Huronian series to be divided by an unconformity into a lower and an upper series, to which the names Cobalt series and Lorrain series were given. Those he considered to be of lower and middle Huronian age or middle and upper Huronian in the event of an older sedimentary series, of which there are traces, being found.

In the present report Laurentian is applied to all batholithic granite or gneiss in the area mapped, and Keewatin to all the schists intruded by them. This use of Keewatin is based upon the facts that the schists so designated consist of volcanic materials and iron formation like the Keewatin rocks of Lake Superior region, their relations to the intrusive batholiths are the same, and what little sedimentary matter has been found in them is too intimately related to the volcanic complex to be possibly Huronian. The granites and gneisses are post-Keewatin and much older than the Cobalt series.

In so far as the Cobalt series rests directly upon Keewatin and Laurentian formations, consists chiefly of erosion materials from these groups, and is lithologically comparable in certain respects to the lower Huronian of other districts, it appears to be lower Huronian. These evidences, however, are not decisive. The discovery of an older sedimentary series above the Keewatin would be

sufficient to make it middle rather than lower Huronian. Such . older series has not been found in place either in this district or at Cobalt, but some indications have been found of its former existence in these or neighbouring districts. Pebbles, apparently of conglomerate, have been found in the conglomerate of the Cobalt series, and numerous fragments of a pure and distinctly clastic quartzite occur in the banded slate (fig. 1, Plate III). The fragmental character of the conglomerate pebbles may be due to brecciation and shearing rather than erosion and sedimentation, but the quartzite is undoubtedly sedimentary. It is unlikely that both conglomerate and quartzite came from the Keewatin, for Keewatin conglomerates are decidedly uncommon, and iron formation is the nearest approximation to a fragmental Keewatin quartzite. It is more probable that they are from a lower Huronian series which, completely eroded in these districts, may persist elsewhere. Such a series is reported by Harvie,[1] who found in the township of Fabre, east of Lake Timiskaming, conglomerate and greywacke older than the Cobalt series, and believed by him to be younger than the Keewatin with which they are infolded. Harvie's discovery . is considerable probability to the opinion that the Cobalt series is middle Huronian.

From its relationships within Gowganda district the age of the quartz diabase cannot be determined more closely than post-Lorrain series. But around Lake Superior, diabase of the same general character is associated with Keweenawan sediments, and between Lake Superior and Timiskaming district diabase occurs at fairly short intervals. All these bodies are thought to be the result of extensive vulcanism in Keweenawan time. It is, therefore, probable that the quartz diabase in Gowganda district is of this age.

The olivine diabase is younger, though probably intruded during the same period of igneous activity.

[1] R. Harvie, Geology of a portion of Fabre township, Que. Dept. of Mines, Que.

ECONOMIC GEOLOGY.

SILVER.

Distribution. Since 1903 silver-cobalt ore has been found locally across the whole width of Nipissing district—72 miles—and for an almost equally great distance north and south. The whole included area is not less than 1,000 square miles. About 650 square miles of this lies within the limits of the accompanying map, chiefly in its southeastern half. The known productive part of these 650 square miles is practically confined to the diabase formation. As the diabase is not uniformly mineralized, it is possible to further limit attention to a number of localities that include most of the known deposits and in which mining camps have been established. James township and portions of Willet, Mickle, Farr, Smyth, and other townships to the east may be called, collectively, Elk Lake district, as the village of Elk Lake forms their business centre. Gowganda village is in like relation to operations in Milner and Nicol. While these two townships include a large majority of the working properties in Gowganda district, others are scattered through Leith, Charters, Lawson, Haultain, Van Hise, and even as far as Morel. A small and isolated silver-bearing area in Leonard township is commonly designated Shiningtree district owing to its proximity to Shiningtree lake. The properties in Speight and Van Nostrand townships, just east and southeast of Banks, lie along the eastern side of Maple mountain, and are known consequently as Maple Mountain district.

In all four districts mineralization rarely extends beyond the diabase formation. The principal vein on the Blackburn or Milleret property at Miller lake lies in conglomerate not far from diabase, and one on the North American claims at Silver lake traverses both diabase and an overlying quartzite, but these are the only important ones known to occur in the Huronian. At Cobalt, on the contrary, most of the ores have been found in Huronian rocks. The significance of this difference is not yet known. Diabase and Huronian are of similar character in both districts, and the Huronian has been little folded in either. But while the diabase throughout Gowganda district bears to the older rocks the relations of tabular sills often exceeding 500 feet in thickness, recent underground

developments at Cobalt are leading to the opinion that the diabase is more irregular in form and may extend to very considerable depths.[1]

Few of the mine workings are over 150 feet deep, so comparatively little is known about the vertical extent of mineralization. Some inferences may be drawn, however, from the general restriction of veins to diabase masses. Apparently veins do not extend far above or below the diabase sills, and the thickness of the latter determines the depth to which they may go. For the same reasons veins are not likely to extend far below the base of the Cobalt series, since diabase sills are not known within either Keewatin or Laurentian, though they commonly rest upon these formations. However, the sills cannot be considered as uniformly thick, especially where they lie upon the unequal surface of the crystalline basement, nor can the possibility of local divergences from the general sill form be entirely excluded.

General Character.—The ores occur in distinct veins of small size. Very large ones are 18 inches or 2 feet wide and the majority are from half an inch to one foot. As a rule they occupy well defined vertical fissures in the diabase or Huronian, extending in nearly straight lines along the surface. Devious, forking veins were seen only on the York property near Silver lake, where they appear to have been influenced by a columnar jointing in the diabase. A large number near Gowganda extend nearly east-west, and others nearly north-south, but for the entire district the strike shows little distinctive regularity. Locally, however, the veins have a conspicuously parallel arrangement. On the Mann property (H.R. 252), west of Gowganda lake, for example, there are four veins only a few yards apart, all of which strike N. 15° E. Seven parallel north-south veins occur within a total width of 300 feet from east to west on the Neeland claim (H.S. 448) in Shiningtree district. In most cases the veins have not been traced for more than 400 feet, owing to their disappearance, junction with other veins, or to the work of stripping becoming too difficult. Occasionally they are longer; a 20 inch vein in the diabase between the two arms of Gowganda lake is traceable for 1,500 feet, crossing one mining claim.

Being largely calcite-filled, the veins erode more rapidly than the country rock and are represented at the surface by crevices,

[1]Can. Min. Jour. Mar. 15, 1911, p. 194.

either empty or filled with soil. In some cases they are concealed by a firm but thin cap, formed by recementation of the weathering products. This is frequently mistaken for diabase by prospectors, and has led to the belief that veins may be 'capped' by diabase. The inconspicuous surface expression is further increased by the moss and forest growth which cover much of the area. But on cliff faces and other exposed rock surfaces, a useful exploratory criterion is afforded by cobalt bloom, a weathering product of smaltite, which produces a characteristic pink or carmine red stain.

Veins and wall-rock are separated in clear-cut manner. The latter has been affected to some extent by vein solutions for a distance of about a foot, and contains some silver and smaltite, chiefly as minute crevice fillings. A considerable part of the low grade ore is obtained from this impregnated wall-rock. Within the veins gangue and ore minerals vary greatly in relative amounts; in many cases the latter are represented only by scattered grains of chalcopyrite. Even in rich veins the ores are not as a rule uniformly distributed, but have been concentrated in patches a few yards in extent, leaving other parts of the same vein practically barren. Some of the phenomenally rich surface discoveries made at Gowganda in 1908 were of this character. A continuous spine of native silver averaging half an inch in width was exposed for about 20 feet along one vein on the Mann property, and slabs of ore, two of which weighed 240 and 160 pounds, respectively, were taken from near the surface of the Reeve-Dobie claims.

Silver is the important metal. Native silver, smaltite, and niccolite are the principal ore minerals, and calcite the chief gangue mineral, though quartz is also present. The proportions in which both gangue and ore minerals are associated is variable, however, and veins in different parts of the district are so unlike, consequently, that their common origin can be recognized only by their like relations to the diabase. Quartz veins carrying chalcopyrite are found in the diabase at Duncan lake. One of the veins on H.S. 448, near Shiningtree lake, consists, in its mineralized part, of massive niccolite unaccompanied by either smaltite, gangue, or silver. Those on H.B. 42, Lawson township, on the contrary, consist chiefly of smaltite, with some silver but little or no niccolite. Some of the largest veins near Gowganda are unmineralized and consist entirely of calcite. A small vein of solid chalco-

pyrite parallels an aplite dyke in the diabase at the United States mine, James township.

Ore within a few feet of the surface differs in no respect from that obtained 150 or 200 feet down—the present depth of mining. Alteration is confined to a surface zone, apparently not often exceeding 6 feet in thickness, where calcite has been leached out, and the sulphides and arsenides oxidized. Smaltite changes to a powdery red erythrite or cobalt bloom, and niccolite to the corresponding nickel bloom, or annabergite, of pale green colour. Limonite and azurite result from chalcopyrite where that mineral is abundant.

Composition of Veins.—On account of the common preponderance of calcite over quartz in the veins, the presence of the latter is often overlooked. However, it is present in most veins and sometimes becomes the chief gangue. Some of the veins that accompany the Duncan Lake diabase sill are composed almost wholly of qu ', with central vugs occupied by calcite. Generally, however, c. .e is more abundant and quartz inconspicuous or even absent. But while they fluctuate relatively in amount their structural arrangement is constant. Quartz always grows from the walls toward the centre, its individual crystals terminating freely in a usually large median space which is filled with calcite.

Barite veins are much less common than those containing calcite. They occur in company with the latter and bear similar relations to the diabase. They consist of quartz and diabase, and appear to be mineralized chiefly with chalcopyrite. One occurs not far from the shaft of the Calcite Lake Mining Company's mine, on L.O. 357, Lawson township. Others have been found in Shiningtree district and in James township.

The ore minerals form a characteristic group of native metals, sulphides, arsenides, and related compounds of cobalt, nickel, silver, and copper. Native silver is of chief economic importance. It occurs in flakes and a network of veinlets that traverse smaltite, niccolite, and calcite in the veins and, in less profusion, a few inches of the adjacent wall-rock. In samples from the White Reserve mine, in Maple Mountain district, it has the appearance of being enclosed by smaltite. Crystal form is known to occur only at the surface of the Mann property (H.R. 252). The first discovery on this claim was a protruding spine of native silver of spongy or arborescent texture, in reality a skeletal arrangement of plates and

string of tiny octahedra arranged in three planes intersecting at right angles to each other. The silver met farther down in unweathered portions of the same vein was of the usual irregular form. Small lumps of argentite were found in a small vein of smaltite on one of the Mann group of claims.

Smaltite ($CoAs_2$) and niccolite ($NiAs$) are the chief arsenides present. Both are massive, and mutually intergrown when found together. At the surface smaltite oxidized to cobalt bloom ($Co_3As_2O_8 + 8H_2O$), niccolite to annabergite ($Ni_3As_2O_8 + 8H_2O$). Imperfect crystals of native bismuth, with striated faces, occur embedded in calcite at the Boyd-Gordon mine, Gowganda, and the Otisse mine, Silver lake; lumps of it were found also on the Lett property at Wapus creek.

Chalcopyrite is more abundant than any of the other minerals, but this fact is obscured by its inferior commercial value. It is particularly common in Elk Lake district, where veins of it are often associated with aplite dykes. The quartz veins in the western part of the district contain this mineral alone and often in considerable masses. It is enclosed by calcite and quartz alike, while the arsenides and native silver appear to associate only with calcite. Disseminated grains of chalcopyrite occur throughout aplite and diabase. Ordinarily it weathers to an earthy brown mass composed largely of limonite, but in veins near Mosher lake, azurite crystals have developed from it.

Other minerals occur in unimportant quantities and more or less sporadically. Specularite is common in James and Corkill townships. Pyrite is wide-spread. Magnetite was observed at one point between the northeast and northwest arms of Gowganda lake. In trenching along one vein, a party of prospectors had uncovered a second cross vein filled with a heavy black veinstone, which proved to be calcite filled with microscopic octahedra of magnetite. Galena is found with chalcopyrite in the quartz gangue. Stibnite occurs some miles south of Shiningtree district.

Judging by its constant growth from the walls toward the interior of the vein, quartz was evidently the first formed vein constituent. Chalcopyrite and galena began to deposit at about the same time, as they occur within the quartz. The remainder of the succession has been worked out by Campbell and Knight,[1] from

[1] W. Campbell and C. W. Knight, Econ. Geol., 1905-6, p. 767.

examination of polished ore surfaces. They find that smaltite and niccolite were deposited next and evidently simultaneously, since the two are intergrown. A period of movement succeeded, during which small fractures were formed. Later, calcite and argentite appeared and the fractures became filled with native silver. Bismuth crystallized later than the silver.

Genesis.—The consistent association of the silver-cobalt veins with quartz diabase sills is the most thoroughly demonstrated and significant fact bearing upon their origin. Nowhere in Gowganda district have veins of this type been found in older rocks except in the immediate vicinity of a diabase sill. They are closely restricted to these intrusions and occur in all the large ones that have been described. Though the formations intruded by the different diabase masses are not the same, the veins associated with one sill do not differ notably from those related to another. It is difficult to escape the conclusion that diabase and ore deposits are intimately related. Such a relation was accepted when exploration in Montreal River district commenced, and has proved serviceable in the search for veins.

The veins intersect both diabase and aplite, hence if derived from the diabase magma, they must represent a still later differentiation product than aplite. The course of differentiation is fairly well known up to the formation of aplite. The original magma was rich in lime, magnesia, and iron, poor in silica and alkalies. With progressive crystallization the residue grew richer in silica and soda at the expense of other constituents up to a certain point, after which soda also began to diminish. Silica maintains a steady concentration. The process is consistent throughout and, if conceived to continue further, would give rise to an end product approximating in composition to a quartz vein. If the facts have been correctly interpreted, this process was accompanied independently by accumulation of calcite-forming material in the residual magma. Calcite appears first in aplite. In two aplite dykes previously discussed, it is so segregated from the aplite that portions of these dykes might be styled calcite veins. Chalcopyrite is found disseminated through diabase and aplite in small amounts. Copper was obtained by analysing a fine-grained sample of diabase, also a sample of augite separated from coarse diabase. It is more abundantly associated with aplite than diabase, frequently accompanying the latter as fissure fillings as well as in disseminated form. The diabase magma

appears capable, therefore, of furnishing through its own differentiation quartz, calcite, and chalcopyrite for the formation of veins.

Analyses of augite from the diabase and of fine-grained varieties of diabase reveal no traces of either cobalt or nickel. Hence, except for their general association with the other vein minerals, there is no evidence that smaltite and niccolite may have come from the diabase.

Certain significant similarities are exhibited by the ore deposits in Gowganda Mining Division and those near Bruce mines farther to the southwest. The veins at Bruce mines are also closely associated with a quartz diabase which cannot be distinguished microscopically from that at Gowganda, and consist of a quartz gangue, with minor amounts of calcite, carrying chalcopyrite, but, so far as known, no smaltite, niccolite, or silver. After studying the differentiation of the Gowganda diabase, concluding that veins carrying quartz, calcite, and chalcopyrite might result thereby, and noting the existing of such veins at Bruce mines in association with diabase, the diabases from Bruce mines and Gowganda were compared microscopically and found to be indistinguishable.

Wall-rock alteration, a fruitful criterion in many districts for determining the nature of the vein solutions, appears of little value in this case, for the diabase has been comparatively little changed near the veins. The solutions may not have been very hot. Campbell and Knight, noting the fact that silver and bismuth when associated in these deposits do not form a natural alloy, have concluded that the solution from which bismuth was precipitated must have been cooler than the melting point of that metal, 269° Centigrade.

Comparison of diabase and aplite series reveals a consistent differentiation of the diabase magma, tending to result, finally, in a concentration of quartz, calcite, and chalcopyrite. And exploration has proved that veins consisting of quartz, calcite, and chalcopyrite occur in every diabase mass of large size and only in or near such masses. These two cognate facts imply that the veins are, wholly or in part, direct products of the diabase magma. Although a source for the silver, cobalt, nickel, and bismuth minerals has not yet been discovered, their restriction to these veins suggests for them a like origin.

Descriptions of Mining Camps.

Although the area over which silver-cobalt minerals are found is large, its geological character is fairly uniform, and the deposits themselves are alike in respect to form and ore content. Hence the method of development is practically the same at all points. Moreover, about the same progress has been made in the several camps, since mining operations were commenced almost simultaneously in each. Work has been confined in many cases to surface exploration, including trenching and test pitting. Shafts have been sunk, upon the more promising properties, to depths of 200 feet or less and horizontal workings begun, usually at a single level. In no case does the total length of underground workings exceed 1,000 feet. The air drills and hoists are operated by small steam plants, power being shared in some cases by adjoining mines. Little water is encountered. Ore is hand sorted and shipped to outside points for treatment.

The following details are based largely upon observations made during 1909. At that time work was almost entirely exploratory. The ore removed from the shafts was being stored until completion of the government road would afford shipping facilities. In only one known case was a future supply of ore in sight large enough to ensure stable operation for any length of time.

Maple Mountain District.—Although this district lies outside the limits of the area mapped, its geological features have been discussed and a brief account of its commercial possibilities is equally desirable. Since the first silver discovery in 1906, a considerable number of claims have been staked along a narrow belt of diabase that extends northward along the east side of Maple mountain, in the townships of Van Nostrand and Speight. This strip represents the protruding eastern edge of a sill which dips westward at 20°-30° between the quartzite beds of which Maple mountain is composed.

During 1909 work was being carried on with good machinery by one company and tentative surface exploration by several others. The White Reserve, or Canadian Ores Limited mine includes mining locations R.S.C. 55 and 56, near Darby lake, in the western part of Whitson township. This property was secured by its present owners from White brothers, who discovered silver upon it in

August, 1906. Twenty-three veins, six of which carry silver, have been found in the diabase. All are vertical and strike N. 60° W. magnetic. Silver and massive smaltite occur in a calcite gangue, which is also accompanied by a little actinolite. Machinery was installed in 1908, a shaft 140 feet deep sunk and 600 feet of drifting done at levels of 75 and 125 feet. Seven tons of ore were shipped in 1909.

Darby Mines Company owns claims H.F. 23, 24, 25, 45, 46, and 47 around Darby lake, also several near Niccolite lake. The original discovery was made in 1906 by Darby brothers. Several sacks of ore were taken from one vein on H.F. 23 in 1907. A large number of veins, some carrying smaltite, have been discovered since then. Assessment work and a little test pitting have been done but there is no machinery on the ground.

Dominion Ores Company. This property lies adjacent to the White Reserve claims. Numerous veins that extend from east-west to southeast-northwest traverse diabase. No machinery has been installed, and only surface exploration has been conducted.

Rubicon Silver Mining Company owns claim J.S. 162, near Anvil lake. Only surface work has been done, resulting in the discovery of several veins running from north-south to northwest-southeast.

Maple Mountain Mining Company owns claims on Niccolite lake. A small engine and 5 × 5 Jenckes hoist are in use. Two shafts have been sunk, but both were full of water when seen.

A sleigh road has been cut from Maple Mountain district to Pork rapids on Montreal river. During summer a nine mile wagon road connects it with Lady Evelyn lake, and a gasoline launch runs thence to Mattawapika falls, where the regular Montreal River steamers are met.

Elk Lake District.—The veins in the Elk Lake district occur in the nearly horizontal diabase sill which covers part of James and neighbouring townships. They are more closely associated with aplite dykes than in any of the other mineralized areas, and contain exceptional quantities of chalcopyrite.

Owing to the number and scattered arrangement of the various operating properties and to lack of time, only the following ones were visited:

Elk Lake Discovery. This property lies near the Elk Lake-Charlton road, 2½ miles from Elk lake. Narrow veins carrying much chalcopyrite and some native silver accompany aplite dykes. Two 50 H.P. boilers, a compressor and hoist have been installed. A shaft has been sunk 154 feet and about 300 feet of drifts run on the level.

Elk Lake Silver Cobalt Mining Company owns claims adjoining those of the Elk Lake Discovery Mining Company. The geological conditions and mineralization are similar to those observed on the latter property. The machinery is also practically identical. Two shafts were begun, one of which is 150 feet deep.

Silver Alliance Mining Company is also located near the Elk Lake Discovery mine, from which it receives steam power for operating one drill. Four shafts have been sunk, one to a depth of 100 feet. In addition to much chalcopyrite, silver is obtained in thin flakes that occupy cracks in the diabase next the veins.

The Gavin Hamilton, Moose Horn, Big Six, Cummings, Langham, and others were not visited.

In the southeast corner of James and adjacent portions of Willet township promising discoveries havé been made, two of which are being operated without machinery. These are known as the Devlin and Lucky Godfrey. Two miles west of this, at Sunday lake in Willet township, silver and smaltite were discovered by Messrs. Tichbourne and Rowlandson.

A small group of properties lying close to Silver lake, in Mickle township, is usually distinguished from those nearer Elk lake as the Silver Lake camp. In this locality the Elk Lake diabase sill slopes southward and westward under Huronian quartzite or arkose. Aplite dykes are numerous. Most of the veins extend nearly east and west. Variable amounts of silver, smaltite, native bismuth, and chalcopyrite are present in a calcite gangue.

Well equipped plants were being operated at the Otisse (F.B. 24), Otisse Currie, and North American (J.S. 174, 175, 176, 177, and 178) mines, which lie close together. About 800 feet of drifting had been done at a depth of 100 feet on the Otisse, and smaller amounts on the others. The North American shaft is located at the foot of a high quartzite ridge under which the diabase passes. An east-west vein carrying some native silver extends up the face of this ridge, cutting both diabase and quartzite.

Diamond drill exploration was being conducted by the Silver Lake Mining Company in diabase at the south end of Silver lake. A short distance north of the lake, on the York claim, chalcopyrite and traces of native silver occur in narrow veins of unusual irregularity, which follow in part cracks resulting from columnar parting of the diabase.

Silver Lake camp is connected with the main wagon road between Gowganda and Elk lake by a spur 2½ miles long. The Devlin and Lucky Godfrey as well as other claims in Willet township are reached by a short wagon road leading from Mountain lake on Montreal river.

Gowganda District.—Most of the mines west of Gowganda lake are located along a ridge of diabase that extends in a north-south direction about half a mile back from the lake shore. The neighbouring rocks are Huronian slate and greywacke. Exceptionally rich surface ore was discovered in August, 1908, and mining development began early in 1909.

Reeve-Dobie. This property includes claims S.W. 3, 4, and 5. All three claims are in diabase, the topography of which is exceedingly rugged. A large number of quartz-calcite veins have been discovered, some of which occur in parallel arrangement at intervals of 10 or 15 feet, their strike being S. 20° W. magnetic. Rich showings of native silver were found at the surface of several of these veins in 1908. Native silver, smaltite, a little niccolite, and chalcopyrite have also been obtained since underground work was commenced. Five shafts have been sunk from 40 to 100 feet on different veins, from which 62 tons of ore have been mined and shipped. A larger amount of low grade ore has been stored. Excellent buildings and roads had been built. During the autumn of 1909 it was proposed to set up a full complement of machinery, part of which had already arrived.

Mann. Mining claims H.R. 250, 251, and 252 are owned by Mann Mines, Limited. The original discovery was made on H.R. 252 in August, 1908, in a 5 inch quartz-calcite vein running nearly east and west. The gangue had been decomposed and leached out at the surface leaving a thick spine of silver visible in the face of a low diabase wall. This rich ore body proved to be limited in size. Since then a group of six parallel veins striking nearly at right angles to the first one have been exposed. The diabase near by is

much shattered, probably by faulting along a north and south plane, east of which the discovery vein could not be traced. Silver has been found also on H.R. 249, known as the Ryan claim, but controlled by the owners of the Mann location. A small plant consisting of 25 horse-power boiler, hoist and steam drills, was at work in 1909. The main shaft had been sunk 60 feet and drifting begun at 56 feet. Much surface exploration had also been performed.

Boyd Gordon mining claim, H.S. 371, adjoining the Mann group, is being operated under the direction of Mr. I. Johnson. Several parallel veins striking in much the same direction as the Mann discovery vein have been found to carry silver, also smaltite and native bismuth. A vertical shaft has been sunk 75 feet; at the 60 foot level 350 feet of drifts have been run along the courses of the veins. A plant consisting of two 50 horse-power boilers, six drill compressor, and hoist is operated.

Bartlett. Bartlett Mines, Limited, owns three different groups of claims at Gowganda, but attention has been given chiefly to those west of the south end of Gowganda lake. Originally discovered by Mr. F. A. McIntosh, the property was sold to the present owners in 1908. Native silver was found at the surface of an east-west quartz-calcite vein on claim H.F. 221. Further development disclosed silver mixed with smaltite in this vein, also in a smaller one lying about 1,700 feet southwest of the first. A well equipped mining plant was installed during the early part of 1909. It consists of two 80 horse-power boilers, a 12-drill compressor, hoists, and electric lighting. One shaft has been sunk 110 feet and a second one 45 feet.

Silvers, Limited. This Company owns H.S. 335, known also as the Armstrong fraction. A shaft has been sunk by hand 100 feet, apparently with the object of tapping a vein that is thought to extend from the adjoining property on the north.

O'Kelly Mines, Limited, were exploring the surface of claims near the south end of Gowganda lake. Some native silver and argentite were found during the summer.

A vein containing high silver values at the surface has been traced about 150 feet on the Milne claim (T.C. 118), and some test pitting done. Argentite and smaltite were also obtained together in massive form in a vein 4 inch wide.

The productive area near Miller lake, a few miles east of Gowganda, is known as Miller Lake district. In geological character

PLATE IV.

Boyd Gordon mine, Gowganda

[illegible] J. Wa[illegible]

this locality approaches Cobalt district more closely than other mineralized portions of Gowganda Mining Division. Diabase rests upon Keewatin rocks as well as Huronian and is overlain in places by the latter. The Huronian beds are much disturbed locally as if intrusion had not been so tranquil as elsewhere. Most of the veins are in the diabase, but the one most productive traverses conglomerate. Native silver, smaltite, and niccolite, with some native bismuth and chalcopyrite occur in a gangue of calcite and a little quartz. Smaltite appears to be most abundant.

Milleret or Blackburn. Mining location R.S.C. 95, owned by the Milleret Silver Mining Company, is underlain by diabase and conglomerate. The conglomerate contains numerous large boulders and is disturbed to an unusual degree; near the mine shaft the dip changes from 15° to nearly vertical within a distance of 100 yards. The principal vein cuts this conglomerate. It dips 70° southeast and extends from northeast to southwest. Mining operations which have been confined largely to this one vein have yielded more substantial returns than any other property in Montreal River district. Its outlook for the future also is promising.

An adit was run from about 200 feet into the side of a conglomerate knob which the vein cuts, and the first 85 feet were stoped down to form an open-cut. A vertical shaft 83 feet deep was sunk in this open-cut and at a depth of 70 feet a drift ran along the vein in both directions. A second shaft has been sunk in diabase near the west side of the claim. One hundred and fifteen tons of ore were shipped during the winter of 1909-10.

Gates mining claims R.S.C. 90, 91, 93, and 94 are known as the Gates property. Silver associated with smaltite was found in calcite veins cutting the diabase on R.S.C. 90. Two shafts, one 100 feet deep, the other 45 feet deep, have been sunk on two different veins 40 feet apart that parallel each other in an east-west direction.

Bonsall. Work on claims R.S.C. 82, 83, 84, 85, 86, 87, 88, and 89 was suspended when visited in September, 1909. A shaft had been sunk 60 feet and drifting begun at the 56 foot level. Much surface exploration had also been performed. Numerous calcite veins had been found, most of them striking about northeast-southwest. Native silver, smaltite, niccolite, and bismuth were obtained at the surface and to a depth of 25 feet.

A promising find of silver was made during 1909 at the surface of a vein on the Morrison property, some distance south of Miller lake.

In June, 1910, examination was made of two properties in the northwestern portion of Lawson township, where discoveries have been made more recently than at Gowganda or Miller lake. The Calcite Lake Mining Company have a shaft 103 feet deep in diabase on L.O. 357, following a vein which extends slightly south of east along the surface. At this point the diabase is probably not very thick, for at the foot of the hill on which the shaft is sunk it contains indurated blocks of greywacke slate. The vein is about 3 inches wide and contains native silver and niccolite with much smaller quantities of smaltite and chalcopyrite. A neighbouring vein is filled with barite.

On H.B. 42, about a mile farther southeast, Messrs. A. Perron and Chas. Richardson were test pitting a number of veins that traverse a narrow ridge of diabase which rises through a heavy drift mantle. The first ore, consisting of flakes of silver and massive smaltite in a gangue of quartz and calcite, was found in a shattered east-west vein averaging 6 inches in width, on June 25.

Several other claims in this locality—often called the Lost Lake district—are reported to be equally promising, but were not examined.

During the month of June, 1909, mineralized veins were discovered in the vicinity of Flanagan lake, a small body of water in Leith township southwest of Hanging Stone lake. Only surface exploration has been done thus far, but the results have been satisfactory. The locality was visited by Mr. Burrows, who found the geological conditions quite analogous to those which obtain at Gowganda; a sill and various dykes of diabase are associated with Huronian slate and greywacke. The diabase contains veins from 1 to 2 inches wide that in places carry native silver, smaltite, niccolite, and native bismuth. The veins extend nearly east and west.

Shiningtree District.—An eroded diabase sill overlying Huronian and Keewatin rocks just east of Shiningtree lake has been under exploration for silver-cobalt veins since 1909. A number of discoveries have been made, but development is limited as yet to trenching and test pitting.

A group of seven parallel veins striking at N. 20° E. magnetic have been exposed for lengths of about 200 feet on the Neeland claim (H.S. 448). For about 15 feet the easternmost of these carries flakes of silver, smaltite, niccolite, and chalcopyrite in a quartz and calcite gangue. The westernmost is 7 inches wide and contains 1½ inches of nearly pure, massive niccolite.

A group of eleven claims a short distance east of the Neeland claim were being vigorously explored in 1910 by the Saville Exploration Company. A large number of veins, most of which strike between N. and N. 30° E., have been uncovered. One of these, which has been trenched for 400 feet on H.S. 865, carries smaltite, native bismuth, and chalcopyrite at one point. Silver and argentite have been found in small quantities in two small veins lying southeast of this large one. The first discovery of silver is reported to have been made in May, 1909.

Smaltite is found rather abundantly on other claims near Spider and Bobs lakes.

Shiningtree district is difficult of access. A trail connects it with Gowganda. It can also be reached from Gowganda Junction (Oshawong lake), on the Canadian Northern Ontario railway, by means of the winter road between that point and Gowganda, or by several long canoe routes.

COPPER.

In Elk Lake district, west of Nest lake and near Duncan lake, veins related to the quartz diabase carry unusual amounts of chalcopyrite associated chiefly with a quartz gangue. The showings are rich and have attracted the attention of some prospectors. This occurrence of chalcopyrite is interesting, owing to the fact that at Bruce mines chalcopyrite-bearing quartz veins are associated with a quartz diabase like what is found in this area. But none of the veins yet found are more than a few inches wide and are of no commercial value.

IRON.

The Keewatin iron formation on the east side of Fournier lake, in Leonard township, contains some bands which may prove rich enough to be mined as iron ore. The main part of the formation consists of imperfectly banded siliceous formation of dull grey colour, alternating with chloritic and sericitic schist, which strike

nearly due north and south and dip 85° west. Certain bands or slender lenses carry enough iron oxide to be nearly black and strongly magnetic. The largest, including minor lean bands, is from 40 to 50 feet wide, and persists as a succession of thin lenses for 1,000 feet along the strike. This rich band is crusted superficially with limonite, but a little below the surface seems to be siliceous iron formation heavily impregnated with magnetite and hematite. Picked samples are reported to have yielded 52 per cent metallic iron.

Nearly all of the range is controlled by Mackenzie and Mann, Limited. In September, under the management of Mr. Fournier, a camp accommodating twenty-five men had been constructed. Trenches had been run across the iron formation at intervals of about 100 feet so as to determine the superficial extent of the ore body. A sleigh road was to be constructed to the main Gowganda-Oshawong Lake road and a diamond drilling outfit brought from Burwash lake. Drilling was expected to commence in January, 1911.

Small bodies of iron ore, for the most part of no commercial importance, have been found elsewhere in Gowganda area. The largest of these lies west of Nest lake and a short distance north of the present mapped area. Its size is not known, but excellent samples of hematite have been obtained from it.

Specular ore was seen on mining claim T.R. 2009, near the northeast end of Firth lake, occupying a fissure in the Keewatin. The ore is of good quality, but the outcrop is of insignificant size, the fissure being only about 2 feet wide, and no ore occurring in either the chlorite schist or reddish granite which lie on either side.

Specular ore also occurs in the basal conglomerate of the Huronian series, filling the interstices between the pebbles where an original cement was deficient. At the south end of Kenisheong lake the conglomerate appears at the water's edge, and the hematite may be observed while paddling near shore. The same thing occurs at the narrows on Duncan lake, just south of the central expansion. In neither case is the ore in commercially valuable quantity.

ASBESTOS.

As stated earlier, small bodies of olivine-bearing intrusions occur at several localities in the Keewatin. These give rise by decomposition to serpentine, and also contain small veins or stringers

of asbestos. Seams averaging one-eighth of an inch in width are common near Serpentine lake, also at a few points west of Obushkong lake. None of these bodies, however, are extensive enough or the asbestos in sufficiently large veins to tempt development. Near Mount Sinclair, however, Mr. George Rahn, of Erie, Pa., is said to have discovered asbestos of workable quality. It may contain larger olivine-bearing intrusives than those now known, and asbestos may, therefore, be a latent resource of the region.

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CANADA
DEPARTMENT OF MINES
GEOLOGICAL SURVEY BRANCH

HON. ROBERT ROGERS, MINISTER; A. P. LOW, DEPUTY MINISTER;
R. W. BROCK, DIRECTOR.

SELECTED LIST OF REPORTS AND MAPS
(SINCE 1885)
OF SPECIAL ECONOMIC INTEREST

THE GEOLOGICAL SURVEY

Report of the Mines Section:

No. 245. Report of Mines Section, 1886.		No. 662. Report of Mines Section, 1897.	
272 " "	1887.	698 " "	1898
*300 " "	1888.	718 " "	1899
301 " "	1889.	744 " "	1900
334 " "	1890.	800 " "	1901
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602 " "	1895.	971 " "	1905
625 " "	1896.		

Mineral Production of Canada:

No. *414	Year 1886.	No. *422.	Year 1893.	No. 719.	Year 1900
*415	" 1887.	*555	" 1894.	719a	" 1901
*416	" 1888.	*577	" 1895.	813	" 1902
*417	" 1889.	*612	" 1896.	861	" 1903
*418	" 1890.	*623	" 1886-96.	896	" 1904
*419	" 1891.	*640	" 1897.	921	" 1905
*420	" 1886-91.	*671	" 1898	981	" 1906
*421	" 1892.	*686	" 1899		

Mineral Resources Bulletin:

No. *818.	Platinum.	No. 860.	Zinc.	No. 881.	Phosphate.
851.	Coal.	869.	Mica.	882.	Copper.
*854.	Asbestos.	872.	Molybdenum and Tungsten.	913.	Mineral Pigments
857.	Infusorial Earth.	*877	Graphite.	953.	Barytes.
858.	Manganese.	880.	Peat.	984.	Mineral Pigments (French)
859	Salt.				

Report of the Section of Chemistry and Mineralogy:

No. *102.	Year 1874-5.	No. *169.	Year 1882-3-4.	No. 580.	Year 1894
*110	" 1875-6.	222	" 1885.	616	" 1895
*119	" 1876-7	246	" 1886.	651	" 1896
*126	" 1877-8.	273	" 1887-8.	695	" 1898
*138	" 1878-9.	299	" 1888-9.	724	" 1899
*148	" 1879-80.	333	" 1890-1.	821	" 1900.
*156	" 1880-1-2.	359	" 1892-3.	*958	" 1906.

* Publications marked thus are out of print

REPORTS.

GENERAL.

745. Altitudes of Canada, by J. White. 1899.
*972. Descriptive Catalogue of Minerals and Rocks, by R. A. A. Johnston and G. A. Young.
1073. Catalogue of Publications: Reports and Maps (1843-1909).
1085. Descriptive Sketch of the Geology and Economic Minerals of Canada, by G. A. Young, and Introductory by R. W. Brock Maps No. 1084; No. 1042 (second edition), scale 100 m. = 1 in.
1086 French translation of Descriptive Sketch of the Geology and Economic Minerals of Canada, by G. A. Young, and Introductory by R. W. Brock. Maps No. 1084; No. 1042 (second edition), scale 100 m. = 1 in.
1107. Part II. Geological position and character of the oil-shale deposits of Canada, by R. W. Ells.
1146. Notes on Canada, by R. W. Brock

YUKON.

*260. Yukon district, by G. M. Dawson. 1887. Maps No. 274, scale 60 m = 1 in.; Nos. 275 and 277, scale 8 m. = 1 in.
*295. Yukon and Mackenzie basins, by R. G. McConnell. 1889. Map No 304, scale 48 m. = 1 in.
687. Klondike gold fields (preliminary), by R. G. McConnell. 1900. Map No. 688, scale 2 m. = 1 in.
884. Klondike gold fields, by R. G. McConnell. 1901. Map No. 772, scale 2 m. = 1 in.
*909. Windy Arm, Tagish lake, by R. G. McConnell. 1906. Map No 916, scale 2 m. = 1 in.
943. Upper Stewart river, by J. Keele. Map No. 938, scale 8 m. = 1 in. } Bound together
951. Peel and Wind rivers, by Chas. Camsell. Map No. 942, scale 8 m. = 1 in.
979. Klondike gravels, by R. G. McConnell. Map No. 1011, scale 40 ch. = 1 in.
982. Conrad and Whitehorse mining districts, by D. D. Cairnes. 1901 Map No. 990, scale 2 m. = 1 in.
1016. Klondike Creek and Hill gravels, by R. G. McConnell. (French.) Map No. 1011, scale 40 ch. = 1 in.
1050. Whitehorse Copper Belt, by R. G. McConnell. Maps Nos. 1026, 1,041, 1,044, 1,049.
1097. Reconnaissance across the Mackenzie mountains on the Pelly, Ross, and Gravel rivers, Yukon, and North West Territories, by Joseph Keele. Map No. 1099, scale 8 m. = 1 in.
1011. Memoir No. 5 (Preliminary): on the Lewes and Nordenskiold Rivers coal-field, Yukon, by D. D. Cairnes. Maps Nos. 1103 and 1104, scale 2 m. = 1 in.
1228. Memoir No. 31: Wheaton district, by D. D. Cairnes.

BRITISH COLUMBIA.

212. The Rocky mountains (between latitudes 49° and 51° 30'), by G. M. Dawson. 1885. Map No. 223, scale 6 m. = 1 in. Map No 224, scale 1½ m. = 1 in.
235. Vancouver island, by G. M. Dawson. 1886. Map No. 247, scale 2 m. = 1 in.
236. The Rocky mountains, geological structure, by R. G. McConnell 1886. Map No. 248, scale 2 m. = 1 in.
263. Cariboo mining district, by A. Bowman. 1887. Maps Nos. 278-281
*271. Mineral wealth, by G. M. Dawson.
*294. West Kootenay district, by G. M. Dawson. 1888-9. Map No. 303, scale 8 m. = 1 in
*573. Kamloops district, by G. M. Dawson. 1894. Maps Nos. 556 and 557, scale 4 m. = 1 in.

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*Publications marked thus are out of print

574. Finlay and Omineca rivers, by R. G. McConnell. 1894. Map No 567, scale 8 m. = 1 in.
743. Atlin Lake mining division, by J. C. Gwillim. 1899. Map No. 742, scale 4 m. = 1 in.
939. Rossland district, by R. W. Brock. Map No. 941, scale 1,600 ft. = 1 in.
940. Graham island, by R. W. Ells. 1905. Maps No. 921, scale 4 m. = 1 in.; No. 922, scale 1 m. = 1 in. (Reprint).
986. Similkameen district, by Chas. Camsell. Map No. 987, scale 400 ch. = 1 in.
988. Telkwa river and vicinity, by W. W. Leach. Map No. 989, scale 2 m. = 1 in.
996. Nanaimo and New Westminster districts, by O. E. LeRoy. 1907. Map No. 997, scale 4 m. = 1 in.
1035. Coal fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia, by D. B. Dowling.
1093. Geology, and Ore Deposits of Hedley Mining district, British Columbia, by Charles Camsell. Maps Nos. 1095 and 1096, scale 1,000 ft. = 1 in.; No. 1105, scale 600 ft. = 1 in.; No. 1106, scale 800 ft. = 1 in.; No. 1125, scale 1,000 ft. = 1 in.
1121. Memoir No. 13: Southern Vancouver island, by Charles H. Clapp. Map No. 1123 -17 A, scale 4 m. = 1 in.
1175. Memoir No. 21: Geology and ore deposits of Phoenix, Boundary district, by O. E. LeRoy. Maps Nos. 1135 and 1136, scale 400 ft. = 1 in.
1204. Memoir No. 24-E: Preliminary Report on the Clay and Shale Deposits of the Western Provinces, by Heinrich Ries and Joseph Keele. Map No. 1201 -51 A, scale 35 m. = 1 in.
1206. Memoir No. 26: Tulameen Mining district, by Charles Camsell. Maps No. 1195-45 A, scale 1 in. = 1/62500; No. 1196-46 A, scale 1 in. = 1/62500; No. 1197-47 A; No. 1198-48 A, scale 1 m. = 1 in.

ALBERTA

*237. Central portion, by J. B. Tyrrell. 1886. Maps Nos. 249 and 250, scale 8 m. = 1 in.
324. Peace and Athabaska Rivers district, by R. G. McConnell. 1890-1. Map No. 336, scale 48 m. = 1 in.
703. Yellowhead Pass route, by J. McEvoy. 1898. Map No. 676, scale 8 m. = 1 in.
*949. Cascade coal fields, by D. B. Dowling. Maps 8 sheets Nos. 929-936. scale 1 m. = 1 in.
968. Moose Mountain district, by D. D. Cairnes. Maps No. 963, scale 2 m. = 1 in.; No. 966, scale 1 m. = 1 in.
1035. Coal-fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia, by D. B. Dowling. Map No. 1010, scale 35 m. = 1 in.
1035a. French translation of coal-fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia, by D. B. Dowling. Map No. 1010, scale 35 m. = 1 in.
1115. Memoir No. 8-E: Edmonton coal-field, by D. B. Dowling. Maps Nos. 1117-5 A and 1118-6 A, scale 2,640 ft. = 1 in.
1130. Memoir No. 9-E: Bighorn coal basin, Alta., by G. S. Malloch. Map No. 1132, scale 2 m. = 1 in.
1131. Memoir No. 9-E (French translation): Bighorn coal basin, Alta., by G. S. Malloch. Map No. 1132, scale 2 m. = 1 in.
1204. Memoir No. 24-E: Preliminary Report on the Clay and Shale Deposits of the Western Provinces, by Heinrich Ries and Joseph Keele. Map No. 1201 -51 A, scale 35 m. = 1 in.
1220. Memoir No. 29-E: Oil and Gas Prospects of the Northwest Provinces of Canada, by W. Malcolm. Map No. 1221 -55 A, scale 35 m. = 1 in.

SASKATCHEWAN

213. Cypress hills and Wood mountain, by R. G. McConnell. 1885. Maps Nos. 225 and 226, scale 8 m. = 1 in.

*Publications marked thus are out of print.

601. Country between Athabaska lake and Churchill river, by J. B. Tyrrell and D. B. Dowling. 1895. Map. No. 957, scale 25 m = 1 in.
868. Souris River coal-field, by D. B. Dowling. 1902.
1035. Coal-fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia, by D. B. Dowling. Map No. 1010, scale 35 m. = 1 in.
1204. Memoir No. 24-E: Preliminary Report on the Clay and Shale Deposits of the Western Provinces, by Heinrich Ries and Joseph Keele. Map No. 1201—51 A, scale 35 m. = 1 in.
1220. Memoir No. 29-E: Oil and Gas Prospects of the Northwest Provinces of Canada, by W. Malcolm. Map No. 1221 (55 A), scale 35 m. = 1 in.
1225. Memoir No. 30: The Basins of Nelson and Churchill rivers, by W. McInnes. Map No. 1226, scale 15 m. = 1 in.

MANITOBA

264. Duck and Riding mountains, by J. B. Tyrrell. 1887-8. Map No. 282, scale 8 m. = 1 in.
296. Glacial Lake Agassiz, by W. Upham. 1889. Maps Nos. 314, 315, 316.
325. Northwestern portion, by J. B. Tyrrell. 1890-1. Maps Nos. 339 and 350, scale 8 m. = 1 in.
704. Lake Winnipeg (west shore), by D. B. Dowling. 1898. Map No. 664, scale 8 m. = 1 in. } Bound together.
705. Lake Winnipeg (east shore), by J. B. Tyrrell. 1898. Map No. 664, scale 8 m. = 1 in.
1035. Coal-fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia, by D. B. Dowling. Map No. 1010, scale 35 m. = 1 in.
1204. Memoir No. 24-E. Preliminary Report on the Clay and Shale Deposits of the Western Provinces, by Heinrich Ries and Joseph Keele. Map No. 1201-51 A, scale 35 m. = 1 in.
1220. Memoir No. 29-E: Oil and Gas Prospects of the Northwest Provinces of Canada, by W. Malcolm. Map No. 1221 (55 A), scale 35 m. = 1 in.

NORTH WEST TERRITORIES

217. Hudson bay and strait, by R. Bell. 1885. Map No. 220, scale 4 m. = 1 in.
238. Hudson bay, south of, by A. P. Low. 1886.
239. Attawapiskat and Albany rivers, by R. Bell. 1886.
244. Northern portion of the Dominion, by G. M. Dawson. 1886. Map No. 255, scale 200 m. = 1 in.
267. James bay and country east of Hudson bay, by A. P. Low.
578. Red lake and part of Berens river, by D. B. Dowling. 1894. Map No. 576, scale 8 m. = 1 in.
*584. Labrador peninsula, by A. P. Low. 1895. Maps Nos. 585-588, scale 25 m. = 1 in.
618. Dubawnt, Kazan, and Ferguson rivers, by J. B. Tyrrell. 1896. Map No. 603, scale 25 m. = 1 in.
657. Northern portion of the Labrador peninsula, by A. P. Low.
680. South Shore Hudson strait and Ungava bay, by A. P. Low. Map No. 699, scale 25 m. = 1 in. } Bound together.
713. North Shore Hudson strait and Ungava bay, by R. Bell. Map No. 699, scale 25 m. = 1 in.
725. Great Bear lake to Great Slave lake, by J. M. Bell. 1900.
778. East coast, Hudson bay, by A. P. Low. 1900. Maps Nos. 779, 780, 781, scale 8 m. = 1 in.
786-787. Grass River region, by J. B. Tyrrell and D. B. Dowling. 1900.
815. Ekwan river and Sutton lakes, by D. B. Dowling. 1901. Map No. 751, scale 50 m. = 1 in.
819. Nastapoka islands, Hudson bay, by A. P. Low. 1900.
905. The Cruise of the *Neptune*, by A. P. Low. 1905.

* Publications marked thus are out of print.

1006. Report of a Traverse through the Southern Part of the North West Territories, from Lac Seul to Cat lake, 1902, by A. W. G. Wilson.
1080. Report on a Part of the North West Territories, drained by the Winisk and Upper Attawapiskat rivers, by W. McInnes. Map No. 1089, scale 8 m. = 1 in.

} Bound together

1069. French translation: Report on an exploration of the East coast of Hudson bay, from Cape Wolstenholme to the south end of James bay, by A. P. Low. Maps Nos. 779, 780, 781, scale 8 m. = 1 in.; No. 785, scale 50 m. = 1 in.
1097. Reconnaissance across the Mackenzie mountains on the Pelly, Ross, and Gravel rivers, Yukon, and North West Territories, by Joseph Keele. Map No. 1099, scale 8 m. = 1 in.
1225. Memoir No. 30: The Basins of Nelson and Churchill rivers, by W McInnes. Map No. 1226, scale 15 m. = 1 in.

ONTARIO.

215. Lake of the Woods region, by A. C. Lawson. 1885. Map No. 2[illegible] scale 2 m. = 1 in.
*265 Rainy Lake region, by A. C. Lawson. 1887. Map No. 283, scale 4 m. = 1 in.
266. Lake Superior, mines and mining, by E. D. Ingall. 1888 Maps Nos. 285, scale 4 m. = 1 in.; No 286, scale 20 ch. = 1 in.
326. Sudbury mining district, by R. Bell. 1890-1. Map No. 343 scale 4 m. = 1 in.
327. Hunter island, by W. H. C. Smith. 1890-1. Map No. 342, scale 4 m. = 1 in.
332. Natural Gas and Petroleum, by H. P. H Brumell. 1890-1. Map Nos. 344-349.
357. Victoria, Peterborough, and Hastings counties, by F. D. Adams. 1892-3.
627. On the French River sheet, by R. Bell. 1896. Map No. 570, scale 4 m. = 1 in.
678. Seine river and Lake Shebandowan map-sheets, by W. McInnes 1897. Maps Nos. 589 and 560, scale 4 m. = 1 in.
723. Iron deposits along the Kingston and Pembroke railway, by E. D Ingall. 1900. Map No. 626, scale 2 m. = 1 in.; and plans of 13 mines.
*739. Carleton, Russell, and Prescott counties, by R. W. Ells. 1899. (See No. 739, Quebec.)
741. Ottawa and vicinity, by R. W. Ells. 1900.
790. Perth sheet, by R. W. Ells. 1900. Map No. 789, scale 4 m. = 1 in.
961. Sudbury Nickel and Copper deposits, by A. E. Barlow. (Reprint). Maps Nos. 775, 820, scale 1 m. = 1 in.; Nos. 824, 825, 864, scale 400 ft. = 1 in.
962. Nipissing and Timiskaming map-sheets, by A. E. Barlow. (Reprint). Maps Nos. 599, 606, scale 4 m. = 1 in.; No. 944, scale 1 m. = 1 in.
965. Sudbury Nickel and Copper deposits, by A. E. Barlow. (French).
970. Report on Niagara Falls, by J. W. Spencer. Maps Nos. 926, 967.
977. Report on Pembroke sheet, by R. W. Ells. Map No 660, scale 4 m = 1 in.

980. Geological reconnaissance of a portion of Algoma and Thunder Bay district, Ont., by W. J Wilson. Map No. 964, scale 8 m. = 1 in.
1081. On the region lying north of Lake Superior, between the Pic and Nipigon rivers, Ont., by W. H. Collins. Map No. 964, scale 8 m. = 1 in.

} Bound together

992. Report on Northwestern Ontario, traversed by National Transcontinental railway, between Lake Nipigon and Sturgeon lake, by W. H. Collins Map No. 993, scale 4 m. = 1 in

* Publications marked thus are out of print

998. Report on Pembroke sheet, by R. W. Ells. (French). Map No. 660, scale 4 m. = 1 in.
999. French translation Gowganda Mining Division, by W. H. Collins. Map No. 1076, scale 1 m. = 1 in.
1038. French translation report on the Transcontinental Railway location between Lake Nipigon and Sturgeon lake, by W. H. Collins. Map No. 993, scale 4 m. = 1 in.
1059. Geological reconnaissance of the region traversed by the National Transcontinental railway between Lake Nipigon and Clay lake, Ont., by W. H. Collins. Map No. 993, scale 4 m. = 1 in.
1075. Gowganda Mining Division, by W. H. Collins. Map No. 1076, scale 1 m. = 1 in.
1082. Memoir No. 6: Geology of the Haliburton and Bancroft areas, Ont., by Frank D. Adams and Alfred E. Barlow. Maps No. 708, scale 4 m. = 1 in.; No. 770, scale 2 m. = 1 in.
1091. Memoir No. 1: On the Geology of the Nipigon basin, Ont., by A. W. G. Wilson. Map No. 1090, scale 4 m. = 1 in.
1114. French translation. Geological reconnaissance of a portion of Algoma and Thunder Bay district, Ont., by W. J. Wilson. Map No. 964, scale 8 m. = 1 in.
1119. French translation: On the region lying north of Lake Superior, between the Pic and Nipigon rivers, Ont., by W. H. Collins. Map No. 864, scale 8 m. = 1 in.

(1114 and 1119) Bound together.

1160. Memoir No. 17-E: Geology and economic resources of the Larder Lake district, Ont., and adjoining portions of Pontiac county, Que., by M. E. Wilson. Maps No. 1177—31 A, scale 1 m. = 1 in.; No. 1178—32 A, scale 2 m. = 1 in.
1242. Memoir No. 33: Geology of Gowganda Mining division, by W. H. Collins.

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216. Mistassini expedition, by A. P. Low. 1884-5. Map No. 228, scale 8 m. = 1 in.
240. Compton, Stanstead, Beauce, Richmond, and Wolfe counties, by R. W. Ells. 1886. Map No. 251 (Sherbrooke sheet), scale 4 m. = 1 in.
268. Megantic, Beauce, Dorchester, Lévis, Bellechasse, and Montmagny counties, by R. W. Ells. 1887-8. Map No. 287, scale 40 ch. = 1 in.
297. Mineral resources, by R. W. Ells. 1889.
328. Portneuf, Quebec, and Montmagny counties, by A. P. Low. 1890-1.
579. Eastern Townships, Montreal sheet, by R. W. Ells and F. D. Adams, 1894. Map No 571, scale 4 m. = 1 in.
591. Laurentian area north of the Island of Montreal, by F. D. Adams. 1895. Map No. 590, scale 4 m. = 1 in.
670. Auriferous deposits, southeastern portion, by R. Chalmers. 1895. Map No. 667, scale 8 m. = 1 in.
707. Eastern Townships, Three Rivers sheet, by R. W. Ells. 1898.
*739. Argenteuil, Ottawa, and Pontiac counties, by R. W. Ells. 1899. (*See* No. 739, Ontario).
788. Nottaway basin, by R. Bell. 1900. *Map No. 702, scale 10 m = 1 in.
863. Wells on Island of Montreal, by F. D. Adams. 1901. Maps Nos. 874, 875, 876.
923. Chibougamau region, by A. P. Low. 1905.
962. Timiskaming map-sheet, by A. E. Barlow. (Reprint). Maps Nos. 509, 606, scale 4 m. = 1 in.; No. 944, scale 1 m. = 1 in.
974. Report on Copper-bearing rocks of Eastern Townships, by J. A. Dresser. Map No. 976, scale 8 m. = 1 in.
975. Report on Copper-bearing rocks of Eastern Townships, by J. A. Dresser. (French).
998. Report on the Pembroke sheet, by R. W. Ells. (French).
1028. Report on a Recent Discovery of Gold near Lake Megantic, Que., by J. A. Dresser. Map No. 1029, scale 2 m. = 1 in.
1032. Report on a Recent Discovery of Gold near Lake Megantic, Que., by J. A. Dresser. (French). Map No. 1029, scale 2 m. = 1 in.

* Publications marked thus are out of print.

1052. French c... tion report on Artesian wells in the Island of Montreal, by Frank D. Adams and O. E. LeRoy. Maps No. 874, scale 4 m. = 1 in.; No. 375, scale 3,000 ft. =1 in.; No. 876.
1064. Geology of an Area adjoining the East Side of Lake Timiskaming, Que., by Morley E Wilson. Map No. 1066, scale 1 m. = 1 in.
1110. Memoir No. 4: Geological Reconnaissance along the line of the National Transcontinental railway in Western Quebec, by W. J. Wilson. Map No. 1112, scale 4 m. = 1 in.
1144. Reprint of Summary Report on the Serpentine Belt of Southern Quebec, by J. A. Dresser.
1160. Memoir No. 17-E: Geology and economic resources of the Larder Lake district, Ont., and adjoining portions of Pontiac county, Que., by M. E. Wilson. Maps No. 1177-31 A, scale 1 m. = 1 in.; No. 1178-32 A 2 m. = 1 in.
1186. Memoir No. 35: ...issance along the National Transcontinental railway in ...her Quebec, by J. A. Dresser. Map 180-34A, scale 8 ...

... BRUNSWICK.

218. Western New Brunswick and Eastern Nova Scotia, by R. W. Ells 1885. Map No. 230, scale 4 m. = 1 in.
219. Carleton and Victoria counties, by L. W. Bailey. 1885. Map No. 231, scale 4 m. = 1 in.
242. Victoria, Restigouche, and Northumberland counties, N.B., by L. W. Bailey and W. McInnes. 1886. Map No. 254, scale 4 m. = 1 in.
269. Northern portion and adjacent areas, by L. W. Bailey and W. McInnes. 1887-8. Map No. 290, scale 4 m. = 1 in.
330 Temiscouata and Rimouski counties, by L. W. Bailey and W. McInnes. 1890-1. Map No. 350, scale 4 m. = 1 in.
661. Mineral resources, by L. W. Bailey. 1897. Map No. 675, scale 10 m. = 1 in. New Brunswick geology, by R. W. Ells. 1887.
799. Carboniferous system, by L. W. Bailey. 1900. } Bound together
803. Coal prospects in, by H. S. Poole. 1900. }
983. Mineral resources, by R. W. Ells. Map No. 969, scale 16 m. = 1 in.
1034. Mineral resources, by R. W. Ells. (French). Map No. 969, scale 16 m. = 1 in.
1113. Memoir No. 16-E: The Clay and Shale deposits of Nova Scotia and portions of New Brunswick, by H. Ries and J. Keele. Map No. 1153, scale 12 m. = 1 in.

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213. Guysborough, Antigonish, Pictou, Colchester, and Halifax counties, by Hugh Fletcher and E. R. Faribault. 1886.
331. Pictou and Colchester counties, by H. Fletcher. 1890-1.
358. Southwestern Nova Scotia (preliminary), by L. W. Bailey. 1892-3. Map No. 362, scale 8 m. = 1 in.
628. Southwestern Nova Scotia, by L. W. Bailey. 1896. Map No. 641, scale 8 m. = 1 in.
685. Sydney coal-field, by H. Fletcher. Maps Nos. 652, 653, 654, scale 1 m. = 1 in.
797. Cambrian rocks of Cape Breton, by G. F. Matthew. 1900.
871. Pictou coal-field, by H. S. Poole. 1902. Map No. 833, scale 25 ch. = 1 in.
1113. Memoir No. 16-E: The Clay and Shale deposits of Nova Scotia and portions of New Brunswick, by H. Ries and J. Keele. Map No. 1153, scale 12 m. = 1 in.

MAPS.

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YUKON.

*805. Explorations on Macmillan, Upper Pelly, and Stewart rivers, scale 8 m. = 1 in.
891. Portion of Duncan Creek Mining district, scale 6 m. = 1 in.

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894. Sketch Map Kluane Mining district, scale 6 m. = 1 in.
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990 Conrad and Whitehorse Mining districts, scale 2 m. = 1 in.
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1011. Whitehorse Copper belt, scale 1 m. = 1 in.
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1099. Pelly, Ross, and Gravel rivers, Yukon and North West Territories. Scale 8 m. = 1 in.
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278. Cariboo Mining district, scale 2 m. = 1 in.
604. Shuswap Geological sheet, scale 4 m. = 1 in.
•771. Preliminary Edition, East Kootenay, scale 4 m. = 1 in.
767 Geological Map of Crow's-nest coal-fields, scale 2 m. = 1 in.
•791 West Kootenay Minerals and Striæ, scale 4 m. = 1 in.
•792. West Kootenay Geological sheet, scale 4 m. = 1 in.
828. Boundary Creek Mining district, scale 1 m. = 1 in.
890. Nicola coal basin, scale 1 m. = 1 in.
941. Preliminary Geological Map of Rossland and vicinity, scale 1,600 ft. = 1 in.
987. Princeton coal basin and Copper Mountain Mining camp, scale 40 ch. = 1 in.
989. Telkwa river and vicinity, scale 2 m. = 1 in.
997. Nanaimo and New Westminster Mining division, scale 4 m. = 1 in.
1001. Special Map of Rossland. Topographical sheet. Scale 400 ft. = 1 in.
1002. Special Map of Rossland. Geological sheet. Scale 400 ft. = 1 in.
1003. Rossland Mining camp. Topographical sheet. Scale 1,200 ft. = 1 in.
1004. Rossland Mining camp. Geological sheet. Scale 1,200 ft. = 1 in.
1068. Sheep Creek Mining camp. Geological sheet. Scale 1 m. = 1 in.
1074. Sheep Creek Mining camp. Topographical sheet. Scale 1 m. = 1 in.
1095. 1A Hedley Mining district. Topographical sheet. Scale 1,000 ft. = 1 in.
1096. 2A Hedley Mining district. Geological sheet. Scale 1,000 ft. = 1 in.
1105. 4A Golden Zone Mining camp. Scale 600 ft. = 1 in.
1106. 3A Mineral Claims on Henry creek. Scale 800 ft. = 1 in.
1123. 17A Reconnaissance geological map of southern Vancouver island. Scale 4 m. = 1 in.
1125 Hedley Mining district: Structure Sections. Scale 1,000 ft. = 1 in.
Deadwood Mining camp. Scale 400 ft. = 1 in. (Advance sheet.)
1135. 15A Phoenix, Boundary district. Topographical sheet. Scale 400 ft. = 1 in.
1136. 16A Phoenix, Boundary district. Geological sheet. Scale 400 ft. = 1 in.
1161. 28A—Portland Canal Mining district, scale 2 m. = 1 in.
Beaverdell sheet, Yale district, scale 1 m. = 1 in. (Advance sheet.)
1195. 45A Topographical map of Tulameen. Scale 1 m. = 1/62500
1196. 46A—Geological map of Tulameen. Scale 1 m. = 1/62500.
1197. 47A—Sketch map of Law's camp.
1198. 48A—Geological map of Tulameen coal area. Scale 1 m. = 1 in.

ALBERTA.

594-596. Peace and Athabaska rivers, scale 10 m. = 1 in.
•808. Blairmore-Frank coal-fields, scale 180 ch. = 1 in.
892. Costigan coal basin, scale 40 ch. = 1 in.
929–936. Cascade coal basin. Scale 1 m. = 1 in.
963–966. Moose Mountain region. Coal Areas. Scale 2 m. = 1 in.
1010. Alberta, Saskatchewan, and Manitoba. Coal Areas. Scale 35 m. = 1 in.

•Publications marked thus are out of print

1117. 5A—Edmonton. (Topography). Scale ½ m. = 1 in.
1118. 6A—Edmonton. (Clover Bar Coal Seam). Scale ½ m. = 1 in.
Portion of Jasper Park, scale 1 m. = 1 in. (Advance sheet.)
1132. 7A—Bighorn coal-field. Scale 2 m. = 1 in.
1201. 51A—Geological map of portions of Alberta, Saskatchewan, and Manitoba. Scale 35 m. = 1 in.
1221. 55A—Geological map of Alberta, Saskatchewan, and Manitoba. Scale 35 m. = 1 in.

SASKATCHEWAN.

1010. Alberta, Saskatchewan, and Manitoba. Coal Areas. Scale 35 m. = 1 in.
1201. 51A—Geological map of portions of Alberta, Saskatchewan, and Manitoba. Scale 35 m. = 1 in.
1221. 55A—Geological map of Alberta, Saskatchewan, and Manitoba. Scale 35 m. = 1 in.

MANITOBA.

804. Part of Turtle mountain showing coal areas. Scale 1½ m. = 1 in.
1010. Alberta, Saskatchewan, and Manitoba. Coal Areas. Scale 35 m. = 1 in.
1201. 51A—Geological map of portions of Alberta, Saskatchewan, and Manitoba. Scale 35 m. = 1 in.
1201. 51A—Geological map of portions of Alberta, Saskatchewan, and Scale 35 m. = 1 in.
1226. 58A—Geological Map of Nelson and Churchill rivers, Sask., and North West Territories. Scale 15 m. = 1 in.

NORTH WEST TERRITORIES.

1089. Explored routes on Albany, Severn, and Winisk rivers. Scale 8 m. = 1 in.
1099. Pelly, Ross, and Gravel rivers, Yukon and North West Territories. Scale 8 m. = 1 in.
1226. 58A—Geological Map of Nelson and Churchill rivers, Sask., and North West Territories. Scale 15 m. = 1 in.

ONTARIO.

227. Lake of the Woods sheet, scale 2 m. = 1 in.
*283. Rainy Lake sheet, scale 4 m. = 1 in.
*342. Hunter Island sheet, scale 4 m. = 1 in.
343. Sudbury sheet, scale 4 m. = 1 in.
*373. Rainy River sheet, scale 2 m. = 1 in.
560. Seine River sheet, scale 4 m. = 1 in.
570. French River sheet, scale 4 m = 1 in.
*589. Lake Shebandowan sheet, scale 4 m. = 1 in.
599. Timiskaming sheet, scale 4 m. = 1 in. (New Edition, 1907).
605. Manitoulin Island sheet, scale 4 m. = 1 in.
606. Nipissing sheet, scale 4 m. = 1 in. (New Edition, 1907).
660. Pembroke sheet, scale 4 m. = 1 in.
663. Ignace sheet, scale 4 m. = 1 in.
708. Haliburton sheet, scale 4 m. = 1 in.
720. Manitou Lake sheet, scale 4 m. = 1 in.
*750. Grenville sheet, scale 4 m. = 1 in.
770. Bancroft sheet, scale 2 m. = 1 in.
775. Sudbury district, Victoria mines, scale 1 m. = 1 in.
*789. Perth sheet, scale 4 m. = 1 in.
820. Sudbury district, Sudbury, scale 1 m. = 1 in.
824-825. Sudbury district, Copper Cliff mines, scale 400 ft. = 1 in.
852. Northeast Arm of Vermilion Iron ranges, Timagami, scale 40 ch. = 1 in.
864. Sudbury district, Elsie and Murray mines, scale 400 ft. = 1 in.
903. Ottawa and Cornwall sheet, scale 4 m. = 1 in.
944. Preliminary Map of Timagami and Rabbit lakes, scale 1 m. = 1 in.
964. Geological Map of parts of Algoma and Thunder bay, scale 8 m. = 1 in.

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* Publications marked thus are out of print.

1023. Corundum Bearing Rocks. Central Ontario. Scale 17½ m. = 1 in.
1076. Gowganda Mining Division, scale 1 m. = 1 in.
1090. Lake Nipigon, Thunder Bay district, scale 4 m. = 1 in.
1177. 31A—Larder lake, Nipissing district. Scale 1 m. = 1 in.
1178. 32A—Larder lake and Opasatika lake. Scale 2 m. = 1 in.

QUEBEC.

*251. Sherbrooke sheet, Eastern Townships Map, scale 4 m. = 1 in.
287. Thetford and Coleraine Asbestos district, scale 40 ch. = 1 in.
375. Quebec sheet, Eastern Townships Map, scale 4 m. = 1 in.
*571. Montreal sheet, Eastern Townships Map, scale 4 m. = 1 in.
*665. Three Rivers sheet, Eastern Townships Map, scale 4 m. = 1 in.
667. Gold Areas in southeastern part, scale 8 m. = 1 in.
*668. Graphite district in Labelle county, scale 40 ch. = 1 in.
918. Chibougamau region, scale 4 m. = 1 in.
976. The Older Copper-bearing Rocks of the Eastern Townships, scale 8 m. = 1 in.
1007. Lake Timiskaming region, scale 2 m. = 1 in.
1029. Lake Megantic and vicinity, scale 2 m. = 1 in.
1066. Lake Timiskaming region. Scale 1 m. = 1 in.
1112. 12A—Vicinity of the National Transcontinental railway, Abitibi district, scale 4 m. = 1 in.
1154. 23A—Thetford-Black Lake Mining district, scale 1 m. = 1 in.
1178. 32A—Larder lake and Opasatika lake. Scale 2 m. = 1 in.
Danville Mining district, scale 1 m. = 1 in. (Advance sheet.)
1180. 34A—Vicinity of the National Transcontinental railway between the counties of Lévis and Témiscouata, scale 8 m. = 1 in.

NEW BRUNSWICK.

*675. Map of Principal Mineral Occurrences. Scale 10 m. = 1 in
969. Map of Principal Mineral Localities. Scale 16 m. = 1 in.
1155. 24A—Millstream Iron deposits, scale 400 ft. = 1 in.
1156. 25A—Nipisiguit Iron deposits, scale 400 ft. = 1 in.

NOVA SCOTIA.

*812. Preliminary Map of Springhill coal-field, scale 50 ch. = 1 in.
833. Pictou coal-field, scale 25 ch. = 1 in.
897. Preliminary Geological Plan of Nictaux and Torbrook Iron district, scale 25 ch. = 1 in.
927. General Map of Province showing gold districts, scale 12 m. = 1 in.
937. Leipsigate Gold district, scale 500 ft. = 1 in.
945. Harrigan Gold district, scale 400 ft. = 1 in.
995. Malaga Gold district, scale 250 ft. = 1 in.
1012. Brookfield Gold district, scale 250 ft. = 1 in.
1019. Halifax Geological sheet. No. 68. Scale 1 m. = 1 in.
1025. Waverley Geological sheet. No. 67. Scale 1 m. = 1 in.
1036. St. Margaret Bay Geological sheet. No. 71. Scale 1 m. = 1 in
1037. Windsor Geological sheet. No. 73. Scale 1 m. = 1 in.
1043. Aspotogan Geological sheet. No. 70. Scale 1 m. = 1 in.
1153. 22A—Nova Scotia, scale 12 m. = 1 in.

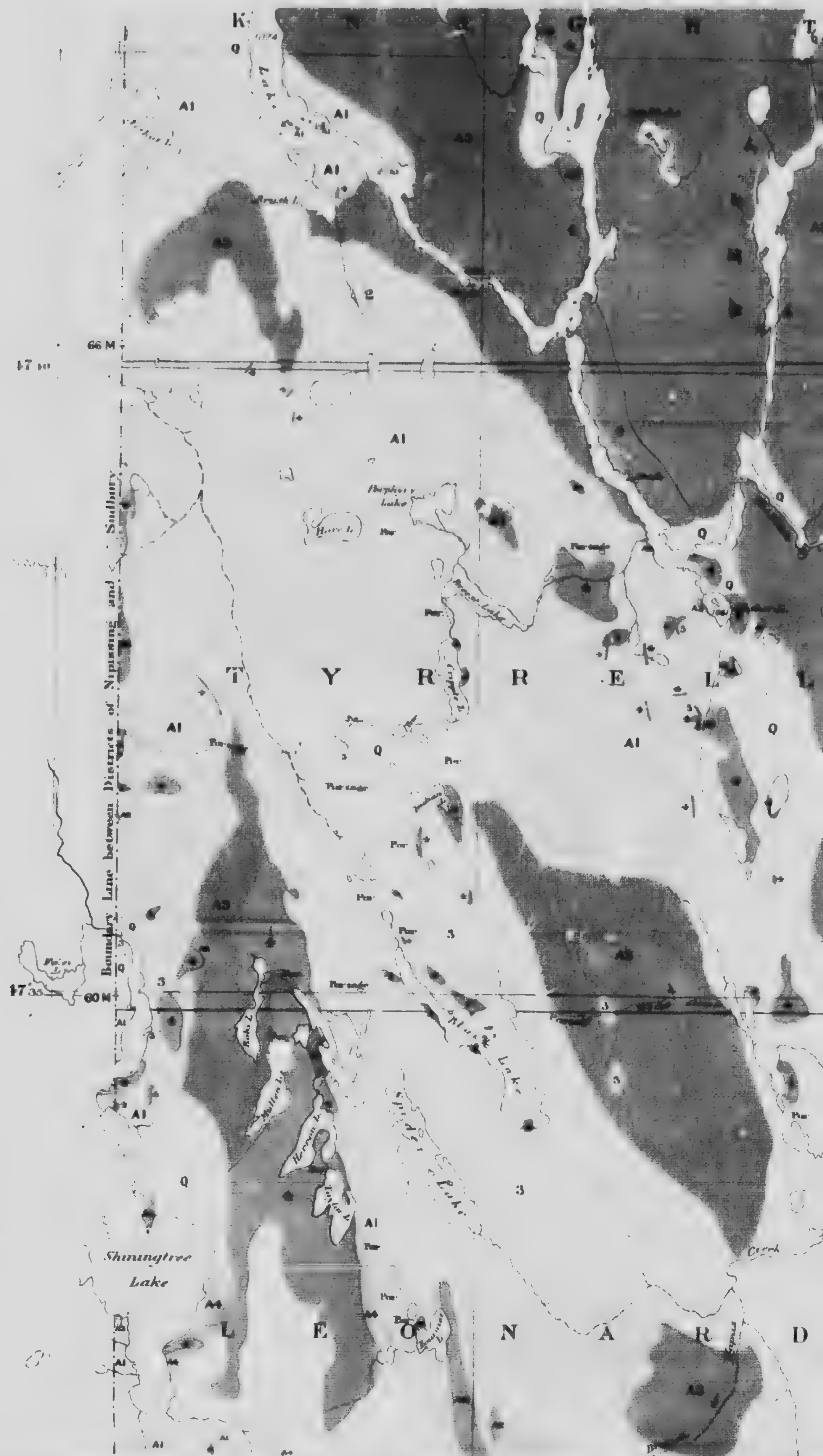
* Publications marked thus are out of print.

NOTE.—Individual Maps or Reports will be furnished free to *bona fide* Canadian applicants.

Reports and Maps may be ordered by the numbers prefixed to titles.

Applications should be addressed to The Director, Geological Survey, Department of Mines, Ottawa.

DEPARTMENT OF MINES – GEOLOGICAL SURVEY



LEGEND

QUATERNARY

PLEISTOCENE
- Q — Glacial drift

PRE-CAMBRIAN

KEWEENAWAN?
- 5 — Olivine Diabase
- 4 — Quartz Diabase

HURONIAN
- A4 — Lorrain series (quartzite, conglomerate and arkose)
- A3 — Cobalt series (conglomerate, greywacke etc.)
- 3 — Rhyolite and Rhyolite Tuff
- 2 — Laurentian (batholiths of granite and gneissic rocks)

KEEWATIN
- E — Harzburgite
- A2 — Iron formation
- A1 — Volcanic complex and metamorphic equivalents
- A — Volcanic complex including Iron formation, etc.

SOURCES OF INFORMATION

GEOLOGY – *W. H. Collins, - - - - 1908-1910*

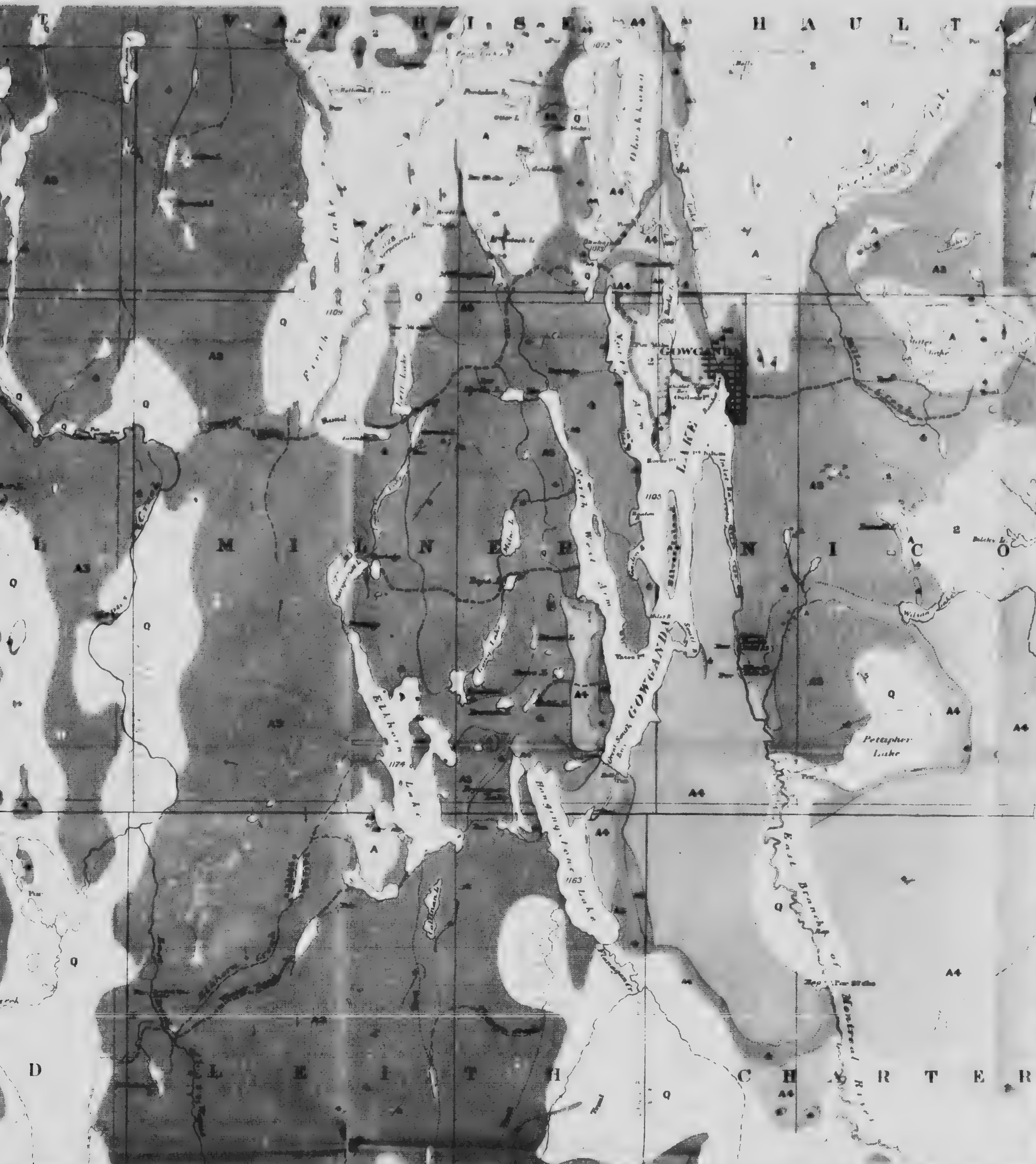
Published maps of Bureau of Mines, Ontario, by A. G. Burrows, - - - - 1906-1909

GEOGRAPHY – *Township outlines and subdivisions from surveys by Department of Lands, Forests and Mines, Ontario*

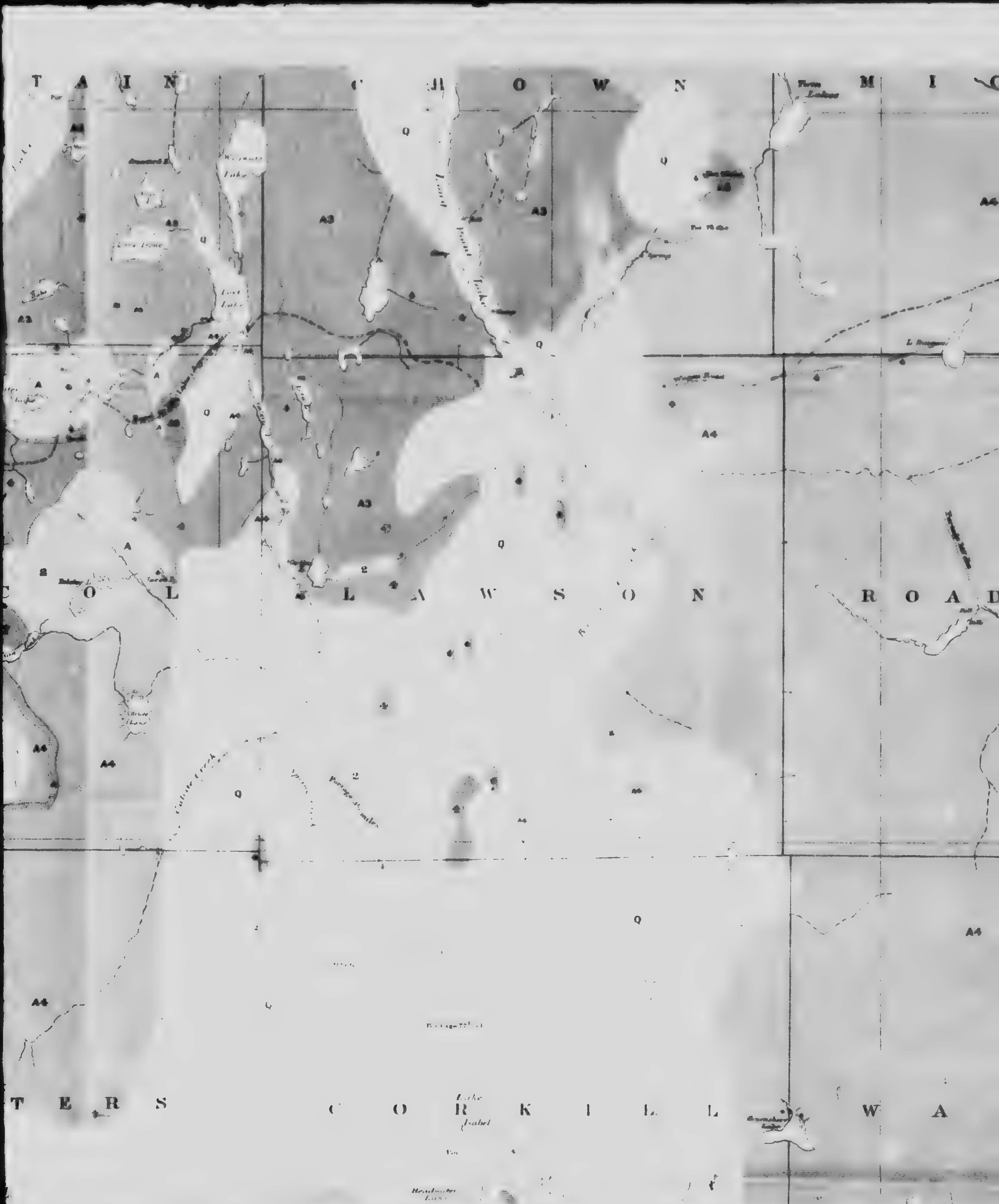
Waterways and drainage from micrometer surveys by W. H. Collins, - - - 1908-1910

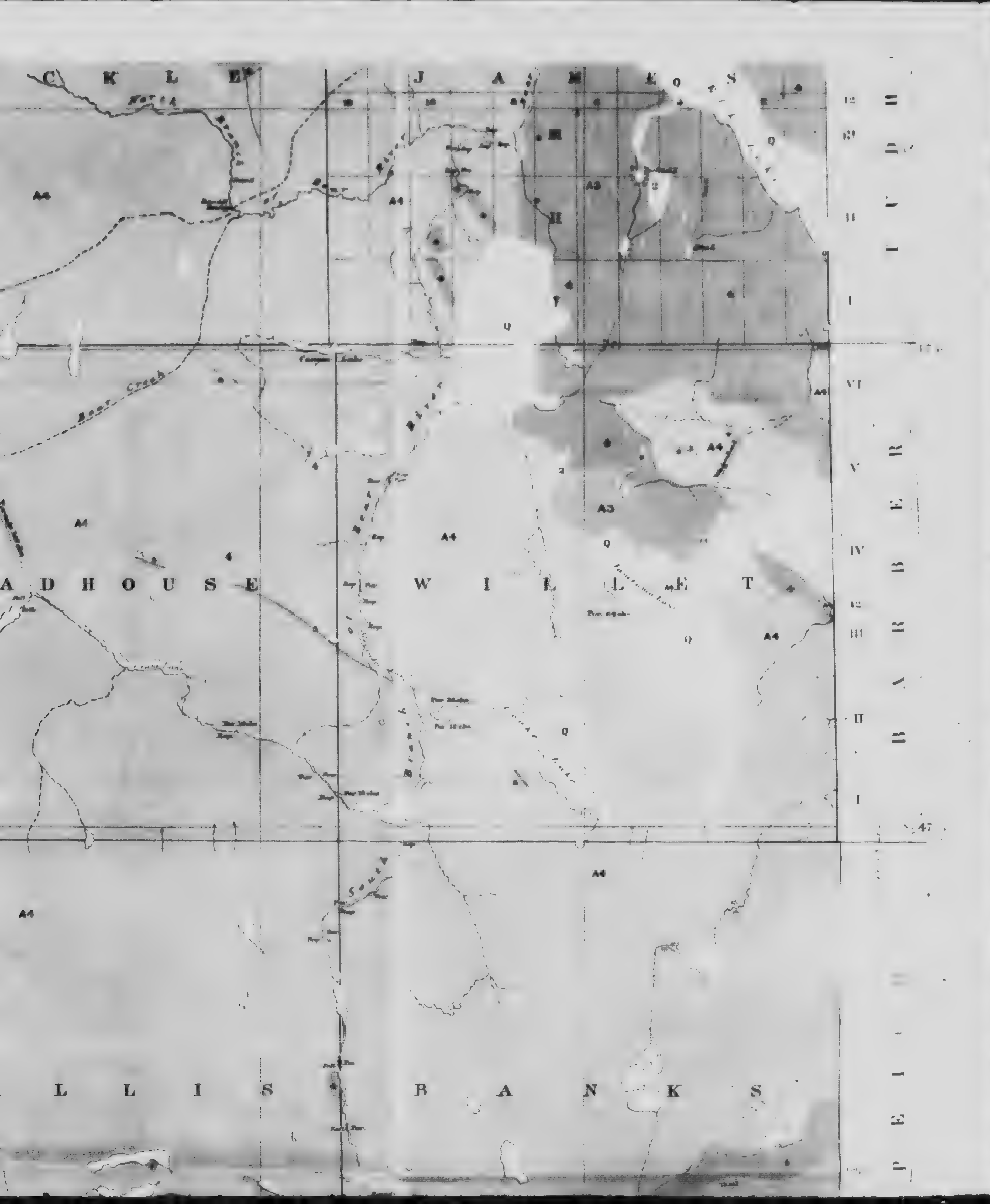
A. Dickison and R. B. Yorston, compilers

VEY



H A U L T A
M I L N E R
N I C O
GOWGANDA
LAKE
GOWGANDA
North Arm
North West Arm
Elkhorn Lake
Firth Lake
Obushkong
Pettapher Lake
Wilson Lake
East Branch of Montreal River
C H A R T E R
L E I T H
D


T A I N
C R O W N
M I C
C O L L A W S O N
R O A D
T E R S
C O R K I L L
W A


C K L E
J A M E S
A D H O U S E
W I L L E T
L L I S
B A N K S
North Branch
Bear Creek
River
South
A4
A3
Q
XII
XI
I
VI
V
IV
III
II

Harzburgite

Iron formation

KEEWATIN

A1

Volcanic complex and metamorphic equivalents

A

Volcanic complex including iron formation, etc.

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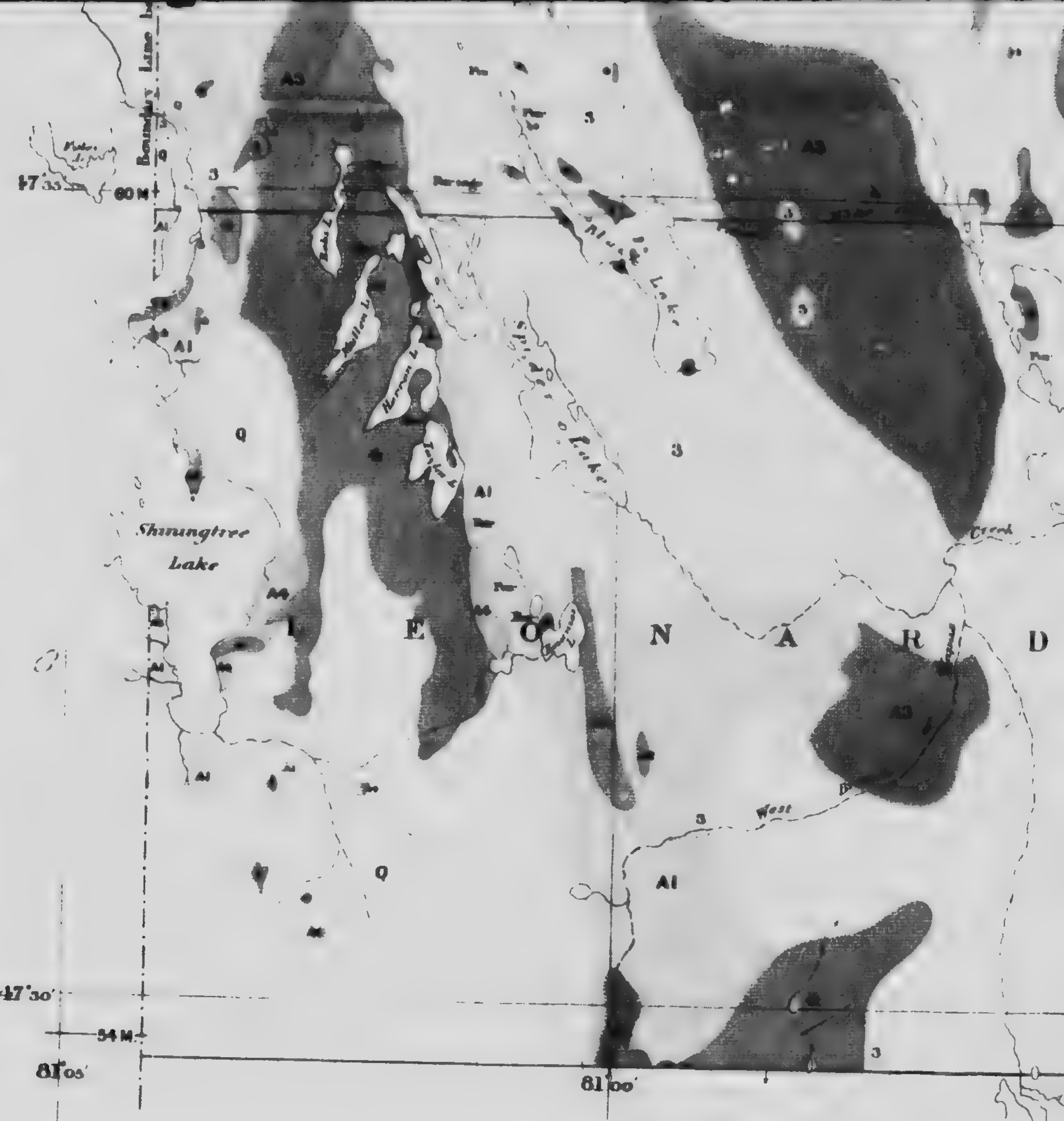
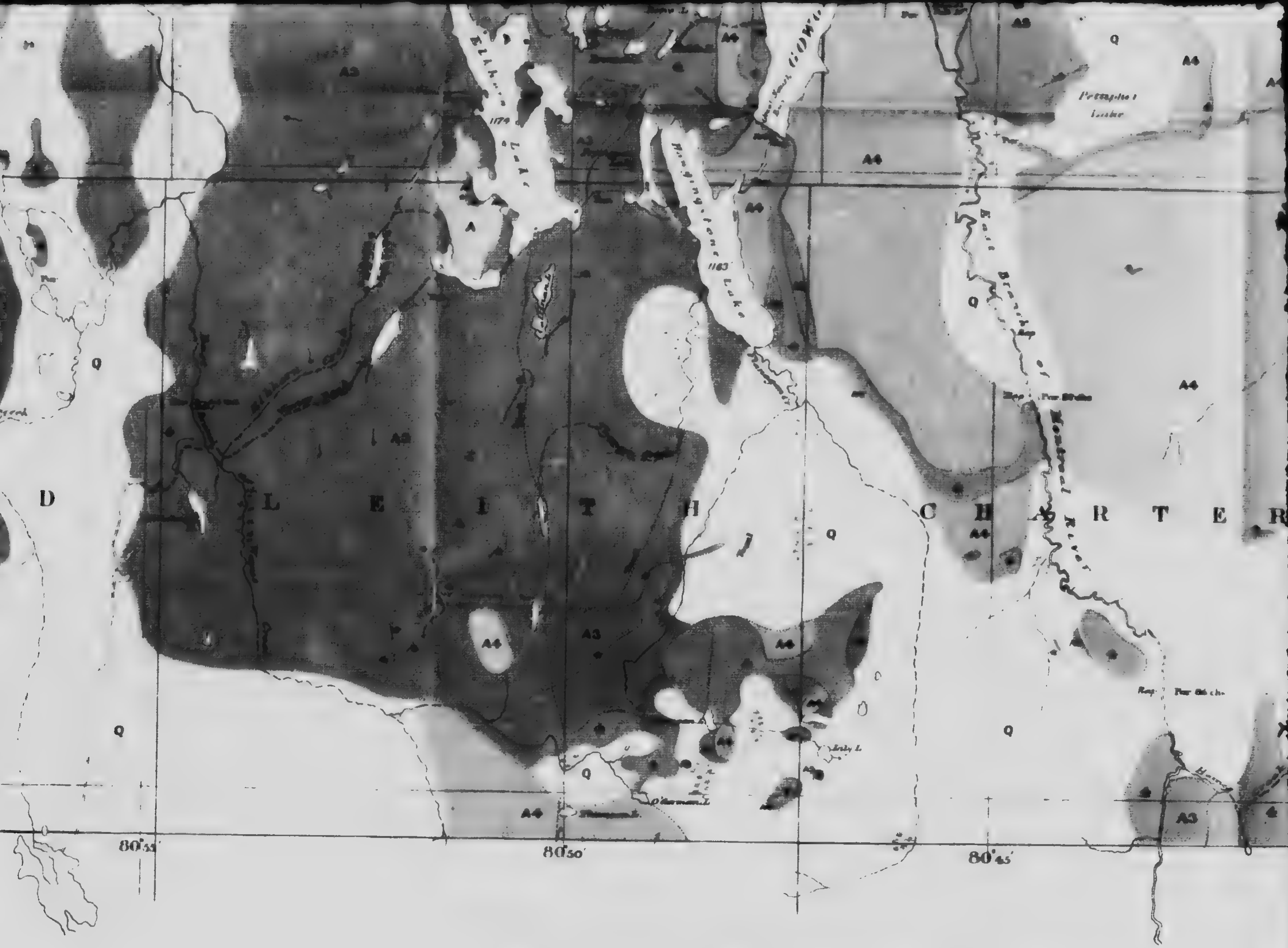
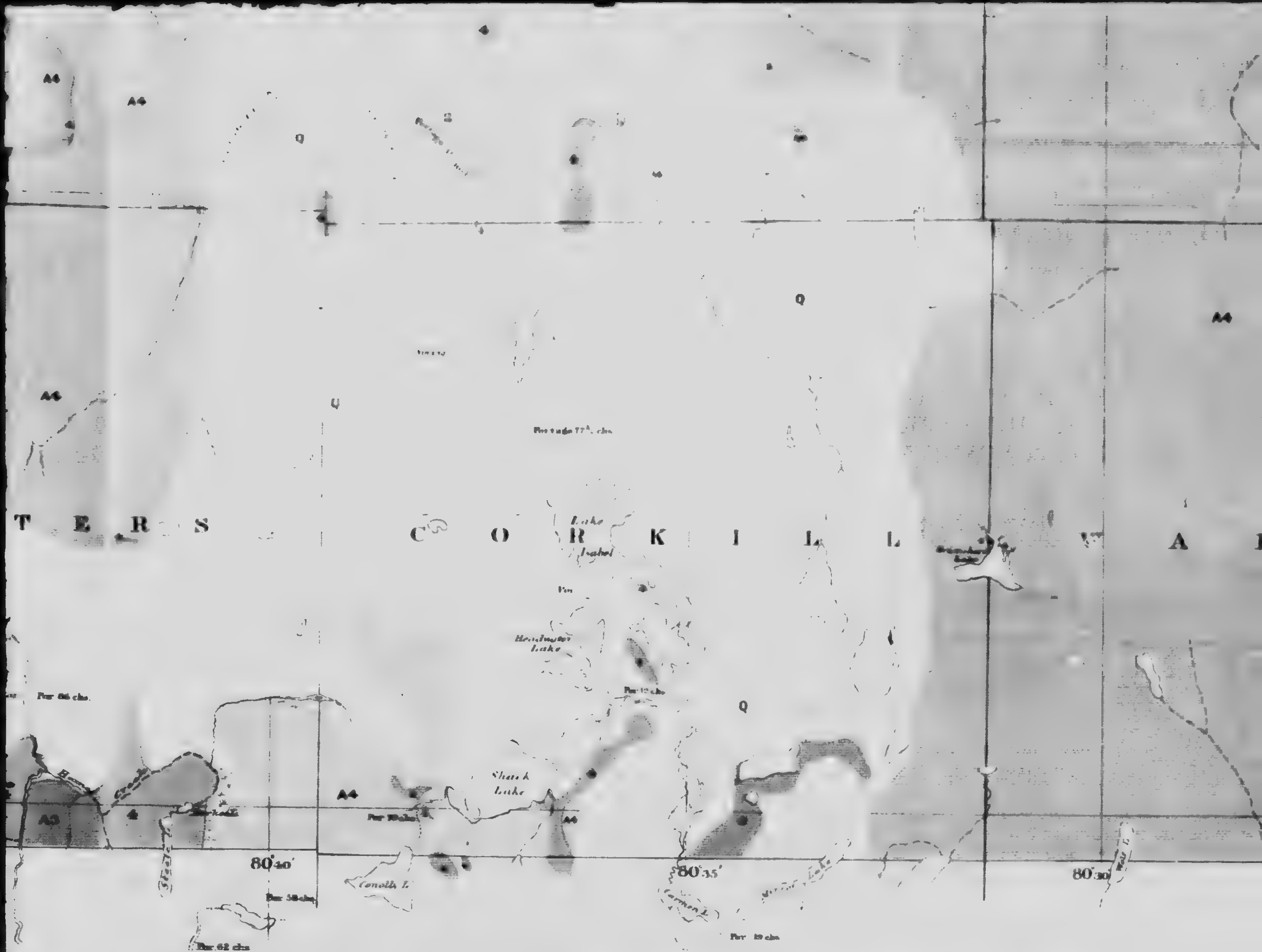


C. O. Senécal, Geographer and Chief Draughtsman



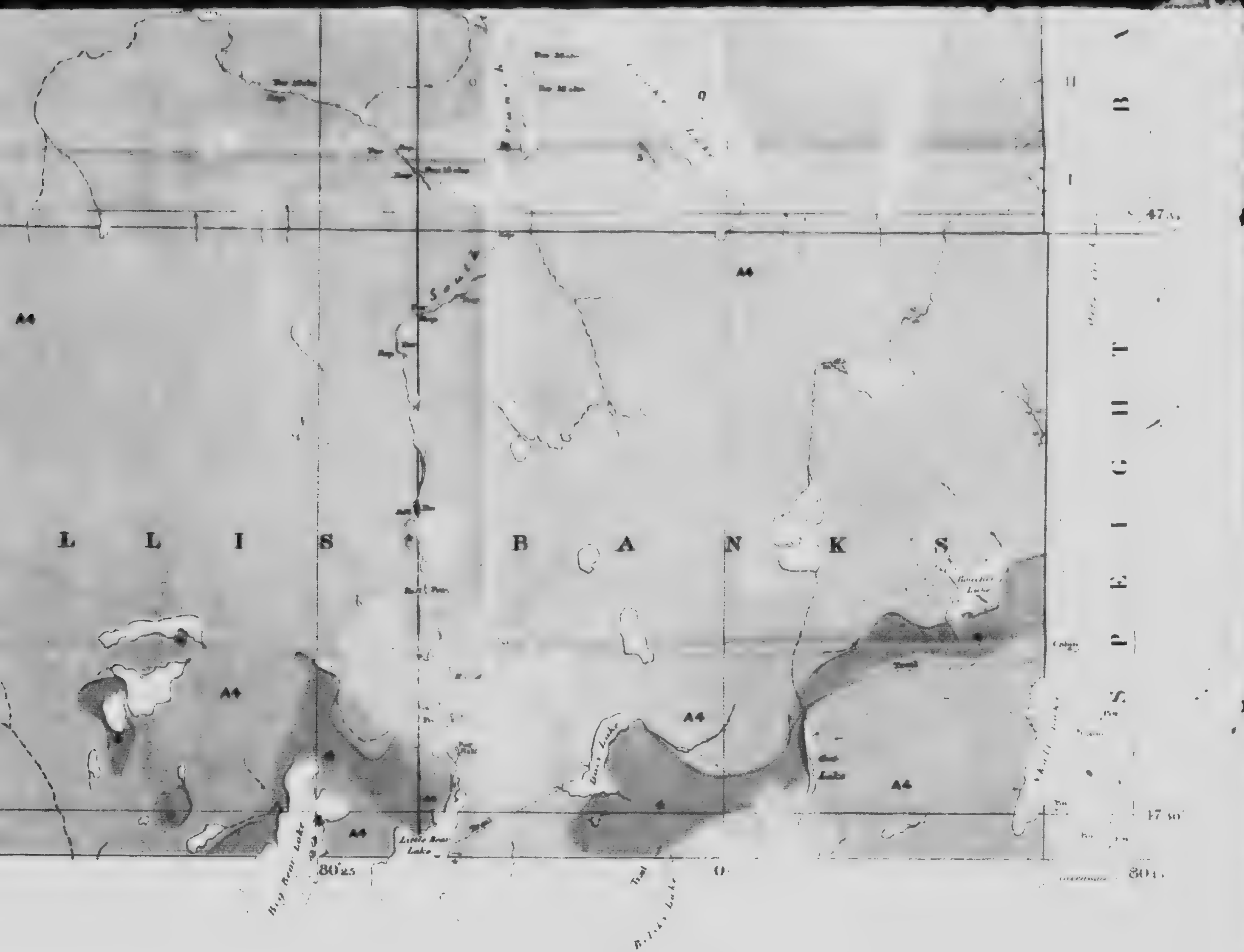
ADVANCE GEOLOGICAL COPY OF MAP OF



MAP OF GOWGANDA MINING DIVISION AND VICINITY, ONTARIO.

Scale of Miles

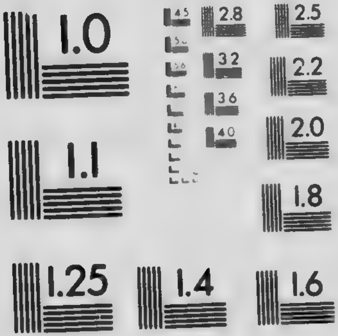
(Issued 1913)



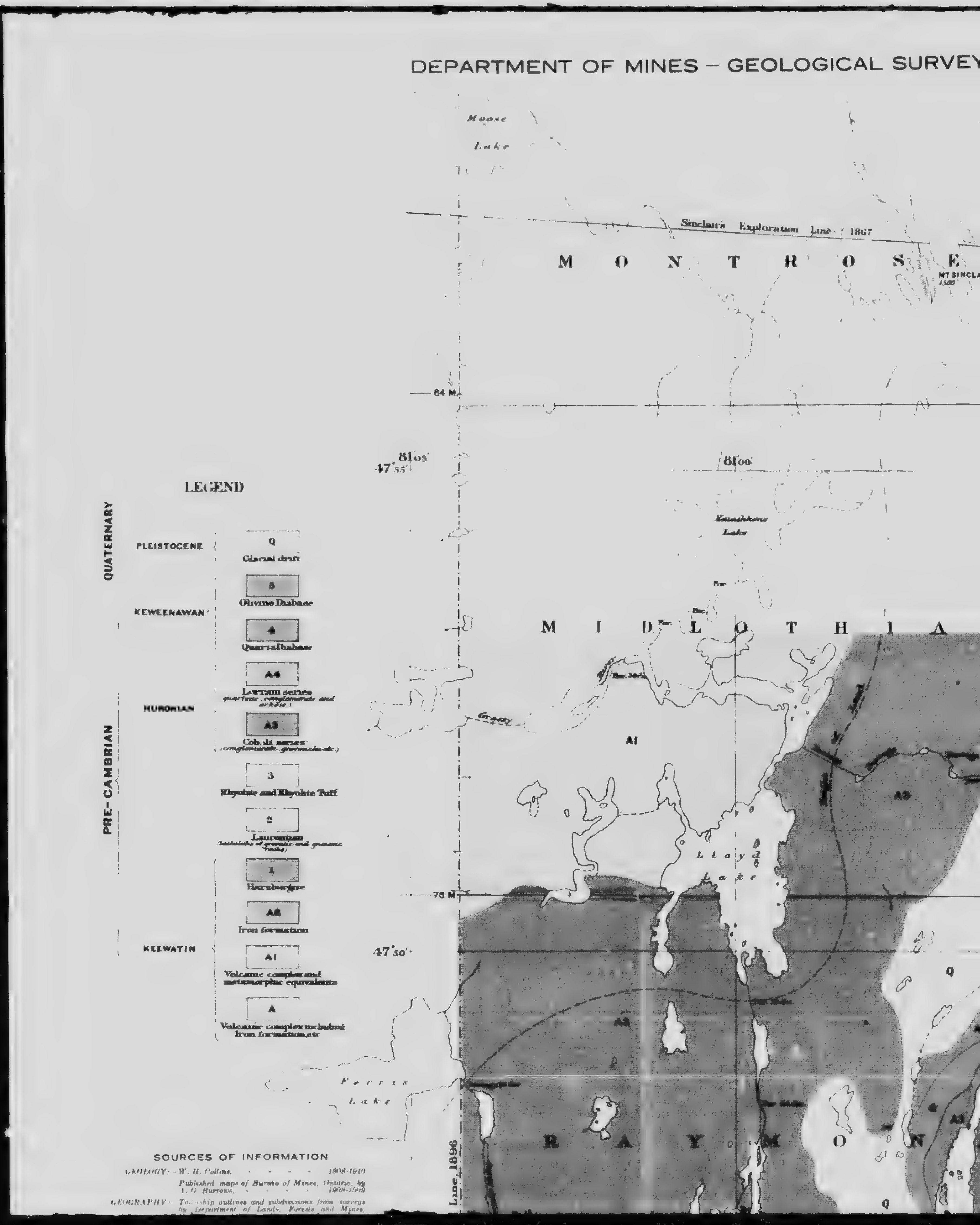
64A—SOUTH HALF
1244a

MICROCOPY RESOLUTION TEST CHART

ANSI and ISO TEST CHART No. 2



APPLIED IMAGE Inc


DEPARTMENT OF MINES – GEOLOGICAL SURVEY
Moose Lake
Sinclair's Exploration Line 1867
M O N T R O S E
84 M.
81°05'
47°55'
81°00'
Kasahkons Lake
M I D L O T H I A
Grassy
A1
A3
Lloyd Lake
78 M.
47°50'
Q
Ferris Lake
R A Y M O N
Line, 1896
LEGEND
QUATERNARY
PLEISTOCENE
Q
Glacial drift
KEWEENAWAN
5
Olivine Diabase
4
Quartz Diabase
PRE-CAMBRIAN
HURONIAN
A4
Lorrain series
(quartzite, conglomerate and arkose)
A3
Cobalt series
(conglomerate, greywacke etc.)
3
Rhyolite and Rhyolite Tuff
2
Laurentian
(batholiths of granitic and gneissic rocks)
1
Harzburgite
KEEWATIN
A2
Iron formation
A1
Volcanic complex and metamorphic equivalents
A
Volcanic complex including Iron formation etc
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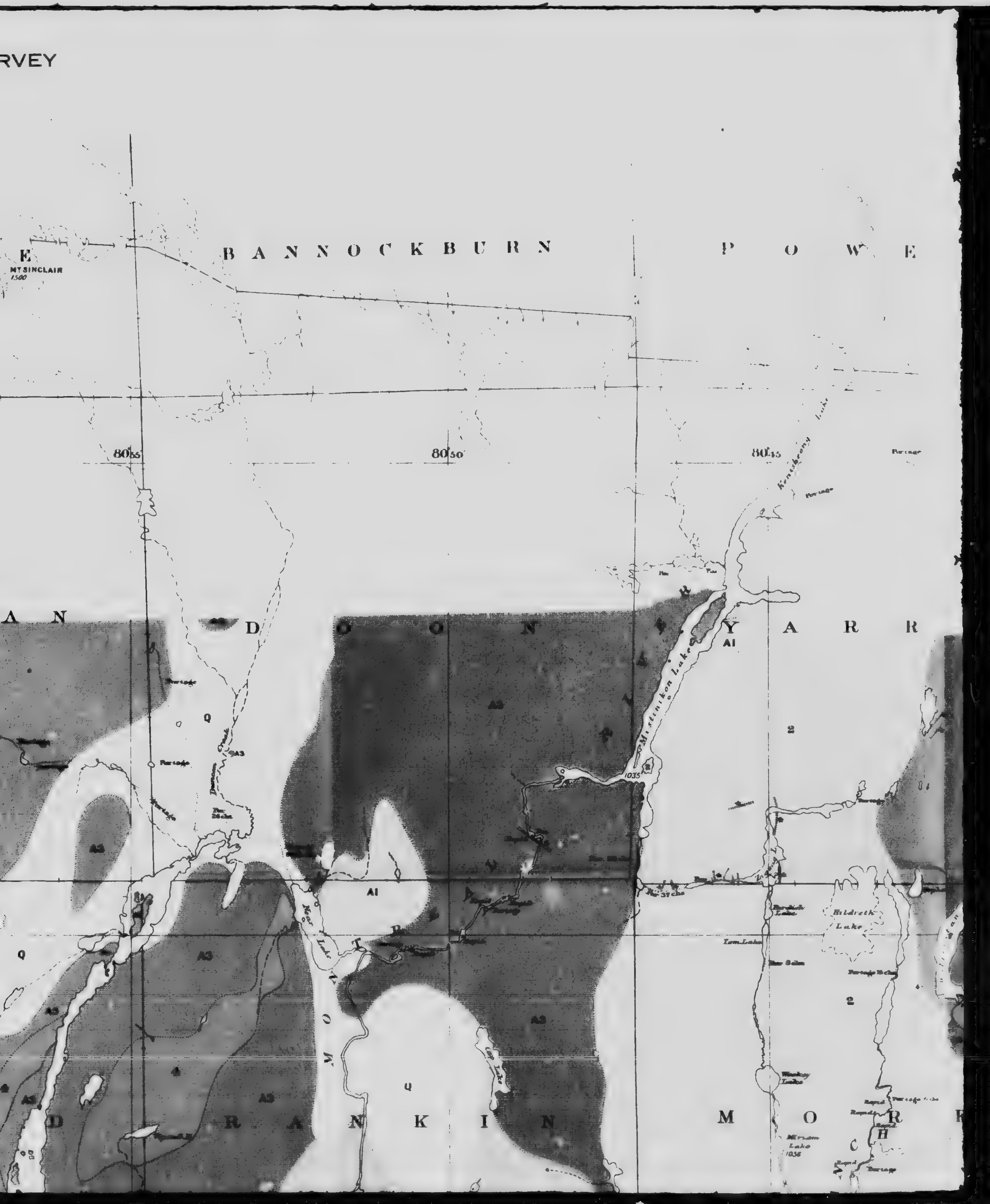
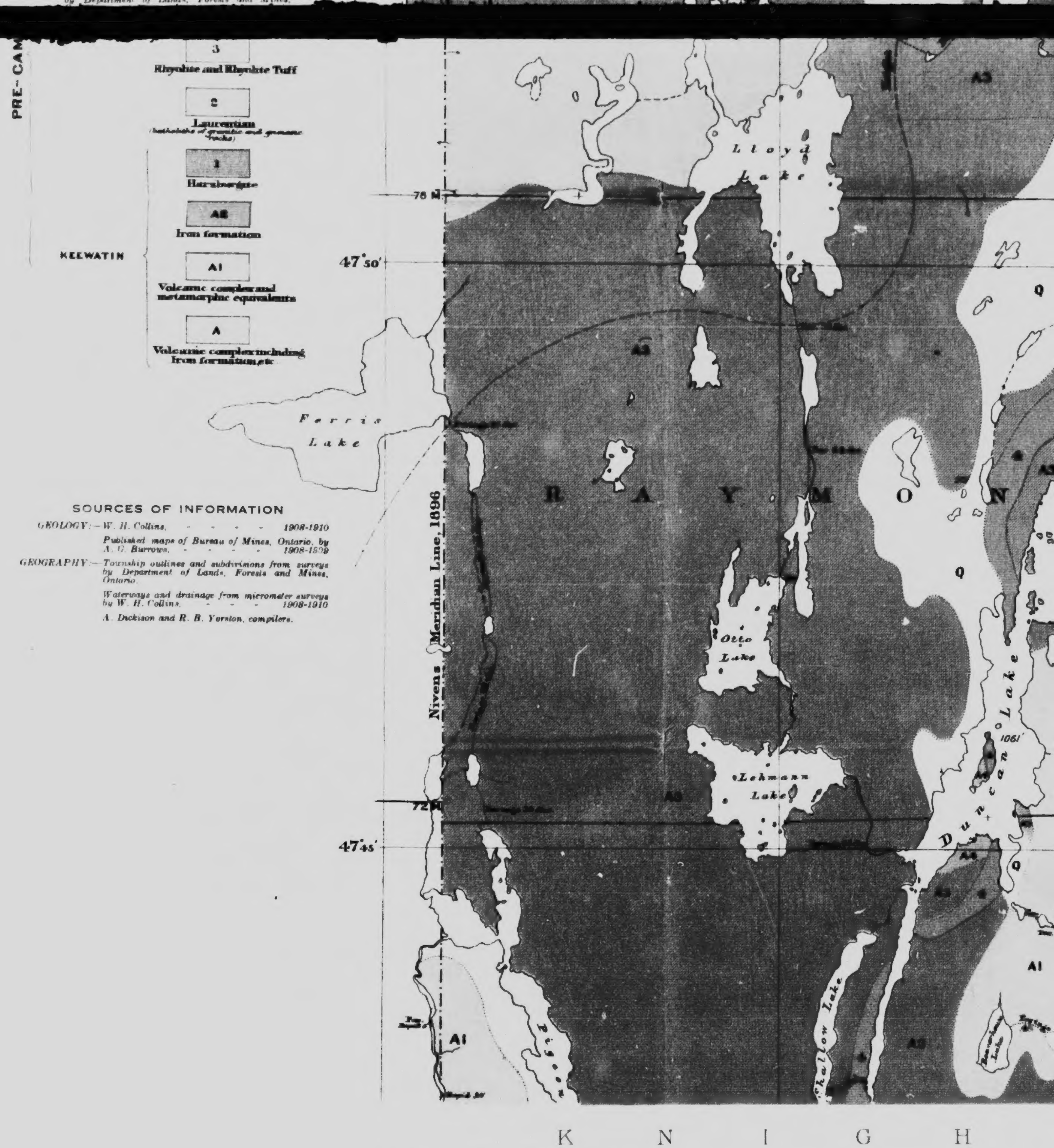


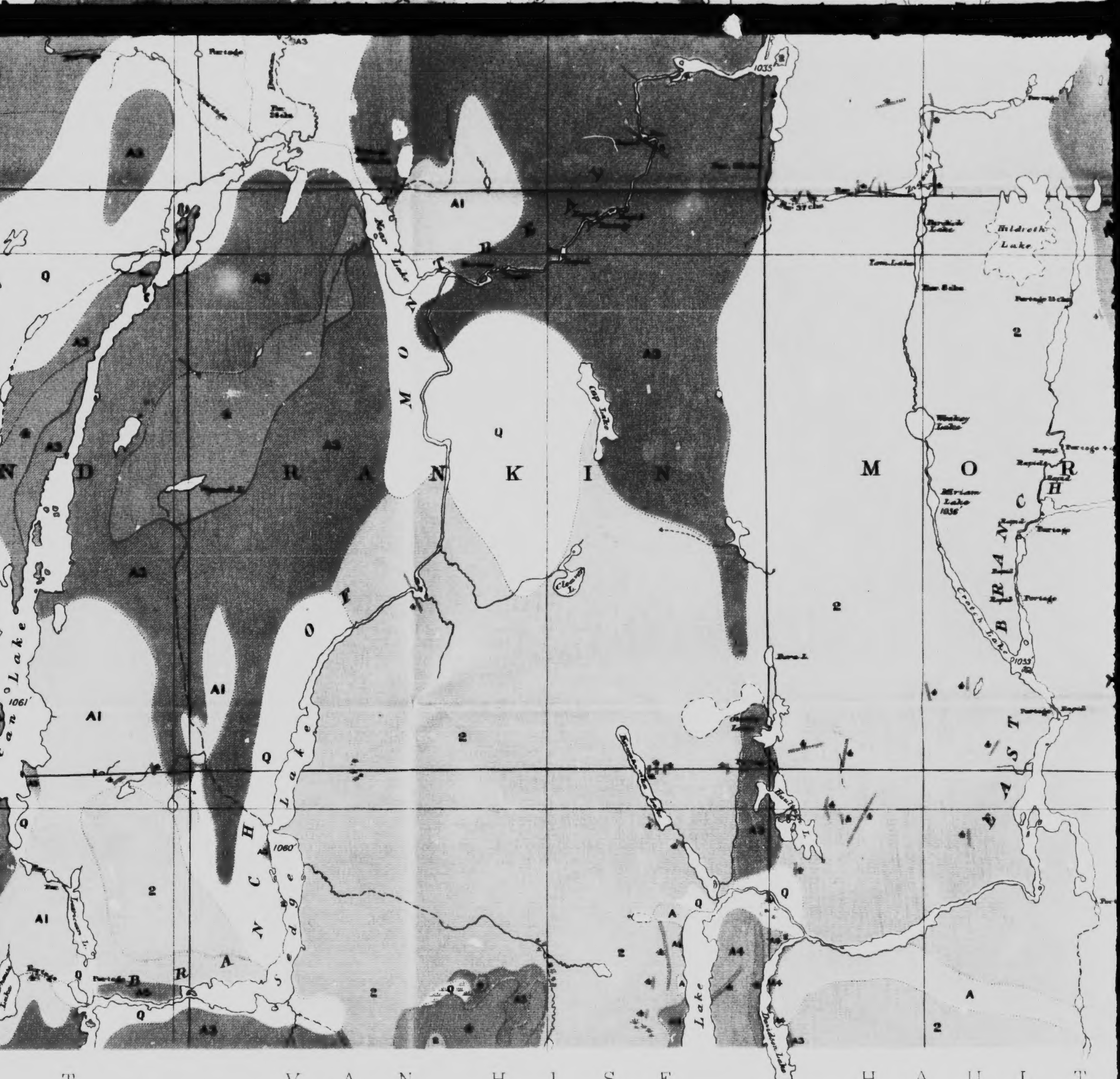
RVEY
E
MT SINCLAIR
1500
BANNOCKBURN
POWE
80 55
80 50
80 45
Kenickeong Lake
Portage
AN
D
O
O
N
YARR
A1
Q
Portage
Duncan Creek
A3
Mistinikon Lake
1035
2
A1
Hildreth Lake
Q
A3
M
O
N
K
I
N
R
A
N
K
I
N
M
O
R
R
H
Wookey Lake
Miriam Lake
1036
Cap Lake

C A I R O
K I M B E R L E Y
S H I L L I N G T O N
Sinclair's Exploration Line 1867
The Forks
80°40'
80°35'
80°30'
Edgar Lake
Portage
Rapid
Nest Lake
Stony Lake
Hildreth Lake
12
10
Q
2
A3


L A V E L L E
G R O S
B L A I N
W I L L I S O N
D A V I D S O N
S H A R P E
S M Y T H
L. Louis
Moose L.
Trail
South Branch
80°25
80°20'



C. O. Senécal, Geographer and Chief Draughtsman



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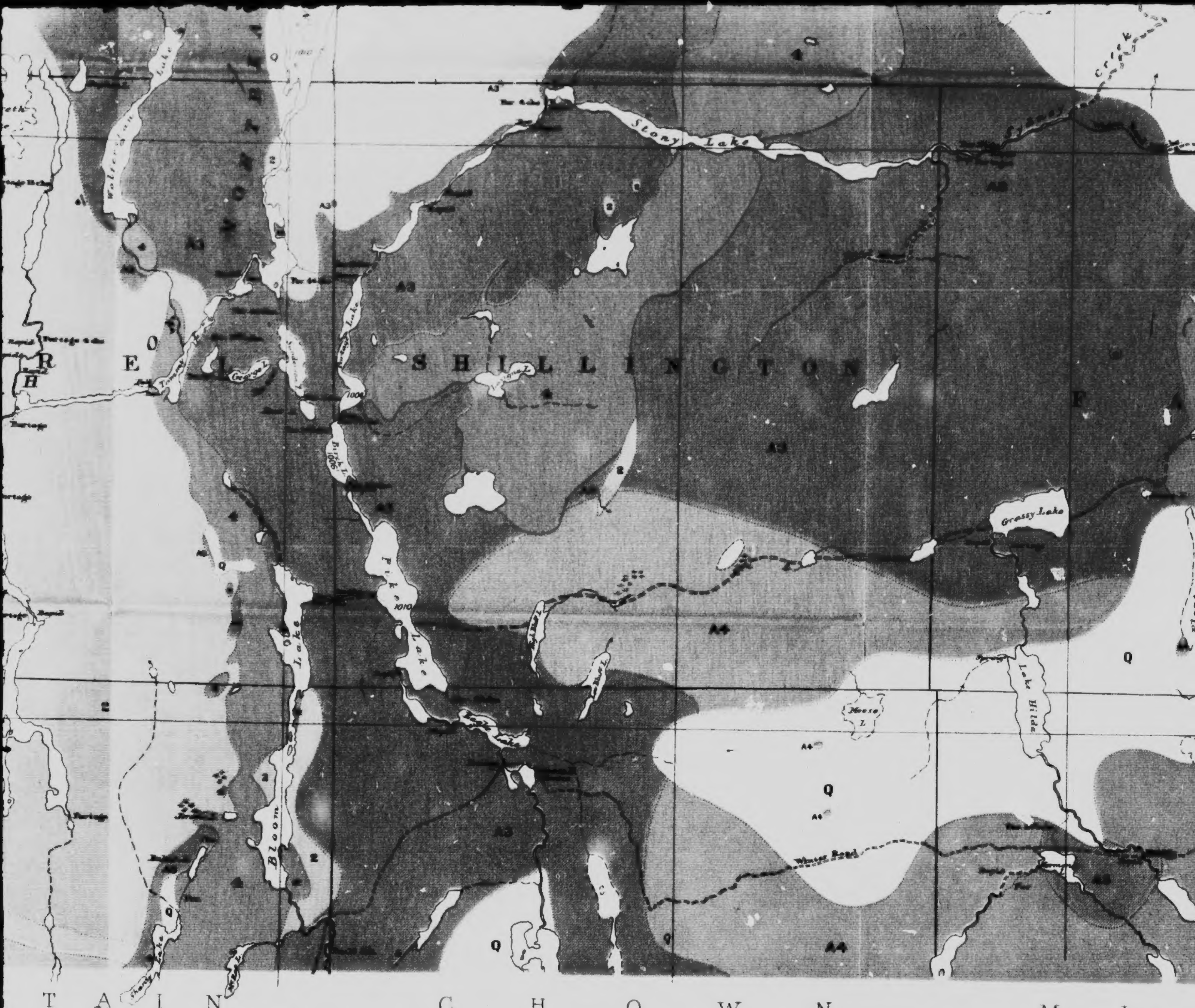

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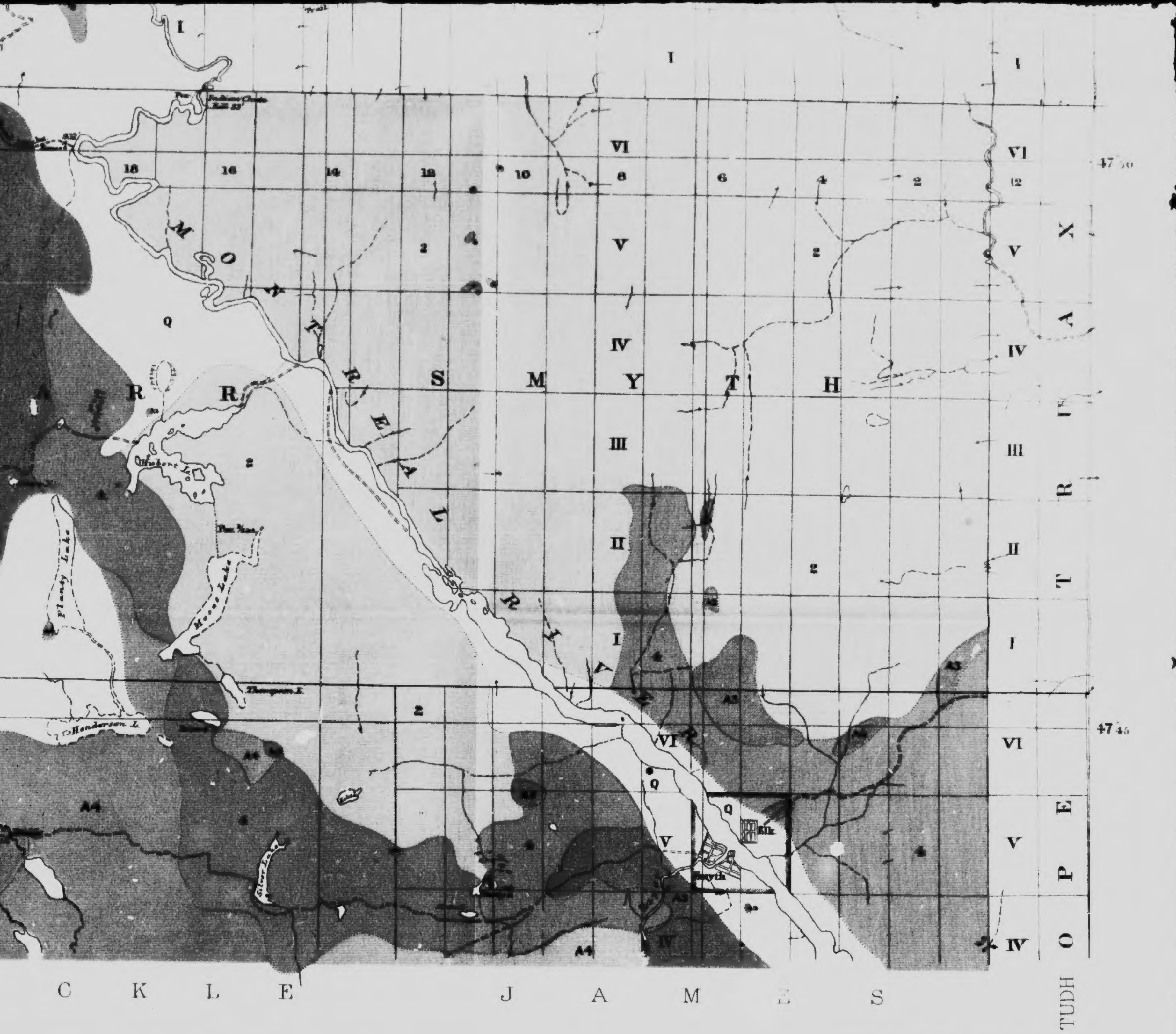
Scale of Miles

(Issued 1913)



64A–NORTH HALF

1244 b